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CURRENT VERSUS GENERATION LIFE TABLES[1]

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THE life table, by one definition, proposes to follow a cohort or generation of say 100,000 persons from the moment of birth, recording, at each year of life, the number of survivors, until the entire group is accounted for by death. From this array of survivors, by suitable devices, several other life table characteristics are computed. One of these, the expectation of life, tells us at each age of life the average number of years of after-lifetime remaining. This life table characteristic is of interest to students of population and of vital statistics; it is also a very helpful instrument in the study of mortality and in the service of advancing public health programs.

There is, however, a fundamental departure from these basic concepts in the usual method of constructing life tables. As a matter of fact, in the computations we do not ordinarily follow through a cohort of 100,000 persons from birth until death, recording the survivors of each year; the customary procedure is rather of the nature of taking a snapshot of *current* mortality at each age, and upon this to construct

[1] Based on a paper presented before the Population Association of America, at Chapel Hill, N. C., May, 1940.

a life table for a hypothetical cohort assumed to be exposed throughout life to this specific mortality at each age. There is a fundamental difference in the two procedures, because in modern times mortality rates have been and still are constantly and very materially improving at the younger ages, with some improvement noted at the middle ages. As a generation or cohort goes through life, conditions change, and those persons who have survived from earlier calendar periods into later years enjoy the benefit of the improved mortality. It is, however, possible on the basis of records going back to the last century, to construct "generation" life tables relating to a cohort traced through life, in accordance with the original conception of a life table. When a table of this kind has been prepared it is of interest to compare it with the corresponding current life tables. We can then observe what effect the improvement of mortality has had on the actual average length of life computed for the cohort, as distinguished from their expectation of life at birth, based on the particular age-specific mortality prevailing at the time of their birth.

PREVIOUS INVESTIGATIONS

It has long been recognized that current life tables cannot be used safely in making forecasts of populations or of annuity values which depend upon future mortality conditions. Thus, Knibbs (1) stated that

> For the accurate prediction of life, however, existing tables are not at all satisfactory, because, representing past experience, they take no account of the fact that the rates of mortality for the major part of life are rapidly diminishing, that is, the probability of life is increasing for every age, say up to 60 for both sexes in many and, probably, in all civilized countries.

Knibbs, accordingly, proposed the construction of "fluent life tables" using age-specific mortality rates projected into the future on the basis of their observed trends. The procedure thus followed by Knibbs is quite different from that of observing the actually recorded mortality of a generation traced from birth.

Another approach to the problem of preparing life tables which may be used in forecasts involving life contingencies was taken by Irving Fisher (2), by Dublin (3), by Dublin and Lotka (13), and by Whelpton (14). The table by Fisher was based upon assumed reductions in death rates from each cause of death as estimated by a number of physicians. In the tables by Dublin and Lotka, an empirical set of reduction factors was applied to the age-specific mortality rates in a

life table based upon actual experience. The reduction factors were arrived at after an examination of recent trends in age-specific mortality and after surveying the experience of communities with exceptionally low mortalities. Consideration was also given to the probable effect that recent advances in medicine and public health practice may have upon the then current death rates at the different stages of life. Practically the same considerations were taken into account by Whelpton. In the preparation of these hypothetical tables, no specific consideration was given to the possibility of extrapolating future mortality rates from the observed for specific generations.

The case for investigating the mortality experience of specific generations for the purpose of estimating the future was clearly discussed by Elderton (9). In attempting any forecast of mortality age by age, the seemingly most obvious procedure would be to project a trend for each age on the basis of the given values for past calendar years. Regarding this, Elderton remarks:

> The method can, however, be criticised; it assumes that the rates of mortality at consecutive ages are independent so that a cause operating in the year c on lives aged x will have no after-effect on the same group of persons the next year $(c + 1)$ when they are a year older. This may prove to be unimportant arithmetically but it must be wrong in some circumstances. Thus, if we assume an immigration of a healthier group of persons at ages 20 to 30, which is discontinued after ten years, we shall trace the effect at subsequent ages through subsequent years, but the sequence of rates of mortality at the same ages (20 to 30) will be seriously disturbed. Again, the circumstances through which people passed during the war were such that it would be surprising if their subsequent mortality were unaffected by this past experience and, in making these remarks, I am not referring only to those who engaged in active warfare: everyone was affected.

These considerations had already prompted the studies of Davidson and Reid (6), and of Derrick (7). Later, Kermack, McKendrick, and McKinlay (10, 11), Cramer and Wold (12), Greenwood (21), and Rhodes (22) gave further thought to the problem. Several of these investigations on the mortality of generations traced from birth have been concerned principally with the search for signs of influences prevailing about the time of birth and early childhood and showing their effect throughout the life of the generation.

More recently, Delaporte (15) using French data, made a study of the mortality of individual generations; he then computed the proportions in each generation that survived from birth to later ages and also the average length of life of the generations. The present paper also

examines these fundamental characteristics of generations, using data for England and Wales and also for the United States. In addition, it contains comparisons of the mortality, survivorship, and mean after-lifetime for each generation studied with the corresponding findings in the life table current in its year of birth.

METHOD OF COMPUTING "GENERATION" LIFE TABLES

It is obviously impracticable to construct a "generation" life table directly by tracing the numbers of survivors in one specific generation of birth, in accordance with the definition cited, for this would require a complete set of observations on all individuals of the cohort followed up through about 100 years. But an essentially equivalent result is obtainable retrospectively by extracting from existing population records the age-specific death rates over a period of years in the past and following the procedure given below.

In computing the generation life tables here presented, advantage was taken of existing current life tables for certain calendar years in the past. The material used in this way was, first of all, the long series of life tables for England and Wales from the period 1871-1880 to 1930-1932. For American data only a shorter series is available, and computations were made on the basis of life tables for Massachusetts starting at 1890 and carried to 1929-1931; another set of computations was made using the life tables for the Original Death Registration States of the United States from 1901 to 1929-1931. The computations in each case were based on the life tables for males and females separately.

The method of procedure is fairly simple. The successive English life tables used were assumed to typify the conditions in the central year of the period covered by each; the life table for 1871-80 was assumed typical of the year 1876, the life table of the period 1881-90 to cover the year 1886, etc. Then, the infant mortality [2] rate of the generation born in 1876 is given by the life table for 1871-80, their

[2] For the sake of brevity, the term infant mortality is here employed to denote the probability of a newborn infant dying within its first year of life. The customary definition of infant mortality is the number of deaths under one year of age per thousand live births during the calendar year. These two definitions are not strictly equivalent, and it is the first of these two definitions which is applicable in the text.

mortality rate at age 10 is given by the life table for 1881-90, and so on up to age 55, when their mortality rate is given by the life table for 1930-32. For the higher ages the mortality rates were assumed to remain unchanged as of 1930-32. This need cause little concern, for it is known that mortality rates at the higher ages have shown relatively little change in the past and are hardly expected to improve materially in the immediate future. The mortality rates in the generation for ages not given by available life tables were estimated by linear interpolation from the mortality rates at these ages in the two adjacent life tables.[3] With a set of age-specific mortality rates thus obtained for the generation born in 1876, it is then an easy matter to find what proportion of the original cohort would survive to successive ages of life, and also to find their average length of life, or, in other words, their average after-lifetime at birth, and also their average after-lifetime at successive ages—that is, to construct a generation life table for those born in 1876.

COMPARISON OF CURRENT AND "GENERATION" LIFE TABLES

1. *Mortality*: The essential facts for the generation of English males born in 1876 are set forth in Table 1. According to the data in this table, the generation was subjected to an infant mortality rate of 158.58 per 1,000[4] the figure indicated in the life table for 1871-80. By the time the generation had attained age 10 in 1886, its mortality rate was only 1.95 per 1,000, less than half of that indicated in the life table for 1871-80. Those of the generation who had survived to age 20 in 1896 experienced a mortality rate of 4.57 per 1,000, which was 27.1 percent less than that prevailing among persons of age 20 in 1876. At age 55, the death rate actually observed for the cohort was 16.14 per 1,000, the corresponding reduction in this case amounting to close to 40 percent. Corresponding data for the generation of English females born in 1876 will be found in Table 2. By comparing the figures in Table 1 with those in Table 2 it will be noted that the percent improvement in age-specific mortality actually experienced, over that prevailing in the year of birth, is consistently better for females than for males.

[3] This procedure does not take into account the year-to-year fluctuations in the mortality rates between the dates to which the successive life tables refer. Any attempt to do so would necessarily involve an amount of labor out of proportion with the effect on the conclusions to be drawn.

[4] See footnote (2).

TABLE 1

Age-specific death rates and survivorships actually experienced by a cohort of males born in England and Wales in 1876 compared with those according to mortality current in the period, 1871-1880

	Attained Age, Years						
	Birth	10	20	30	35	45	55
Age attained by cohort in.....	1876	1886	1896	1906	1911	1921	1931
	Mortality rate per 1,000						
Life table used for actual mortality in cohort	1871–80	1881–90	1891–00	1901–10	1910–12	1920–22	1930–32
Actual mortality in cohort.....	158.58	1.95	4.57	5.66	6.24	8.81	16.14
According to life table, 1871-80.....	158.58	4.01	6.27	9.39	11.28	16.60	26.67
Percent improvement.....	.....	51.4	27.1	39.7	44.7	46.9	39.5
	Survivors out of 100,000 live births						
Actual survivors in cohort.....	100,000	71,919	69,838	66,390	64,457	59,848	53,315
According to life table, 1871-80.....	100,000	70,899	68,003	63,004	59,886	52,237	42,468
Lives saved.....	.....	1,020	1,835	3,386	4,571	7,611	10,847

TABLE 2

Age-specific death rates and survivorships actually experienced by a cohort of females born in England and Wales in 1876 compared with those according to mortality current in the period, 1871-1880

	Attained Age, Years						
	Birth	10	20	30	35	45	55
Age attained by cohort in.....	1876	1886	1896	1906	1911	1921	1931
	Mortality rate per 1,000						
Life table used for actual mortality in cohort	1871–80	1881–90	1891–00	1901–10	1910–12	1920–22	1930–32
Actual mortality in cohort.....	128.73	1.67	4.14	4.84	5.23	6.68	11.74
According to life table, 1871-80.....	128.73	4.03	6.12	8.61	10.00	13.52	20.94
Percent improvement.....	.....	58.6	32.4	43.8	47.7	50.6	43.9
	Survivors out of 100,000 live births						
Actual survivors in cohort.....	100,000	74,933	72,830	69,680	67,953	64,057	58,759
According to life table, 1871-80.....	100,000	73,838	70,795	65,842	62,884	56,017	47,744
Lives saved.....	.....	1,095	2,035	3,838	5,069	8,040	11,015

For example, at age ten, the reduction in mortality amounted to 51.4 percent for males and 58.6 percent for females; at age 30, the corresponding figures were 39.7 and 43.8 percent, and at age 55 they were 39.5 and 43.9 percent.

2. *Survivorship*: The more favorable mortality experienced by the generation in the course of its advancing years, as compared to that prevailing in its year of birth, results in a saving of life which is truly impressive. Thus, the lower panel of Table 1 shows that, if the generation of males born in 1876 started with 100,000 live births, then 71,919 actually[5] lived to reach age ten. This figure is 1,020 more than the number expected to survive to age ten on the basis of mortality conditions observed in their year of birth. In other words, out of the number surviving to age ten, over 1,000, or almost one and one-half percent owed their lives to the improvement in mortality in the decade following their year of birth.

It is interesting to observe the number of lives saved in the cohort as it progressed through life. At age 30, the number of lives saved in the cohort of 100,000 males traced from birth had grown to 3,386, or practically 5 percent of the 66,390 who actually survived. By the time the generation had attained age 55 in 1931, there were 53,315 still alive, and, of these, 10,847, or almost one-fifth, owed their survival to the reduction in mortality since their year of birth. Corresponding results for the generation of females born in 1876 will be found in the lower panel of Table 2.

So far, the generations of males and females born in 1876 have been traced up to age 55 in 1931 on the basis of mortality actually experienced, and the number of survivors have been compared with the situation that would have prevailed if mortality had been static at the various ages as of the year of birth. It would be interesting also to note what the future of these cohorts would be if they were subjected, at the ages past 55, to the actual mortality rates to be observed for these ages in the calendar years when they are attained. But obviously this will require a waiting period of many years. For all practical purposes, however, the mortality rates at the several ages past 55 may be assumed

[5] It will be recognized that the word "actually" as used here and in the sequel is to be understood as referring to a number calculated as described, on the basis of mortalities corresponding to the actual conditions encountered by the generation in its way through life.

to be very similar to those actually recorded in 1931, our last year of observation. The result of a calculation based on this assumption is shown in Fig. 1.

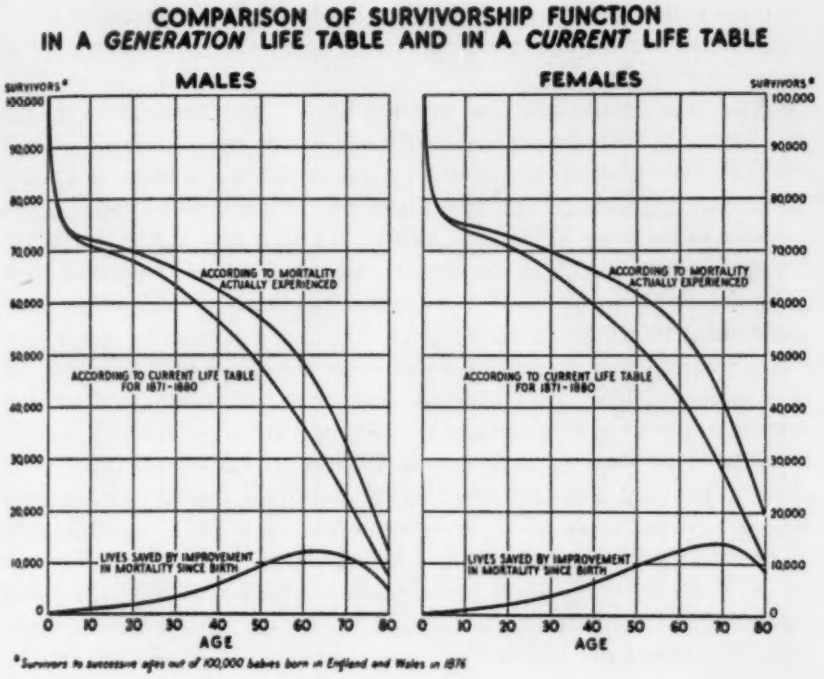
COMPARISON OF SURVIVORSHIP FUNCTION
IN A GENERATION LIFE TABLE AND IN A CURRENT LIFE TABLE
MALES
FEMALES
SURVIVORS*
ACCORDING TO MORTALITY ACTUALLY EXPERIENCED
ACCORDING TO CURRENT LIFE TABLE FOR 1871-1880
LIVES SAVED BY IMPROVEMENT IN MORTALITY SINCE BIRTH
AGE
*Survivors to successive ages out of 100,000 babies born in England and Wales in 1876

FIG. 1

In this figure, the two curves descending from left to right represent survivors to successive ages out of 100,000 live births in 1876. The upper curve shows the actual survivors according to observed mortality up to age 55 in 1931, and beyond this age, the survivors computed on the assumption of no further improvement after 1931. The curve underneath this representes the survivorship column in the life table for 1871-80, based on the then current mortality. The third curve, at the bottom of the figure, is found by taking the difference between the first two curves, and thus represents the lives saved by improvement in mortality from the year of birth up to the age attained. The rise in this curve, which, from what has been said above, continues at least as far as age 55 on the basis of actual observations, is seen to continue to a maximum of

about 12,000 at age 65 in the case of males and to a maximum of about 13,750 at age 70 in the case of females. Inspection of the numbers in the last line of Tables 1 and 2, giving the lives saved by improvement in mortality since the year of birth in 1876, shows greater gains for females than for males at each age. This, of course, reflects the greater relative improvement in the age-specific mortality rates for females, which has already been noted.

The 12,000 male lives thus saved at age 65 constitute almost 30 per cent of the 41,800 who survive to that age on the basis of actual experience; practically the same percentage was found for females at age 65. Insofar as the situation described here for England and Wales applies likewise to the United States, it can be said, with reasonable confidence, that about 30 percent of the persons alive today at age 65 owe their existence to the advances of science and standards of living that have contributed to reduce mortality since their birth. Actually, many persons of age 65 now in our population were born in countries where the expectation of life, at the time of their birth, was undoubtedly below that then current in England and Wales or in the United States. Among these persons, there is good reason to believe that considerably *more* than 30 per cent owe their lives to the improved conditions they have enjoyed on the score of their betterment in geographic environment, in addition to the general advances in science.

3. *Years of life*: With information available regarding the actual mortality and survivorship of the cohort born in 1876, it becomes possible to compute not only the average length of life of this generation, but also the average years of life lived after any attained age. The results may then be compared with the expectation of life at the attained ages according to current life tables constructed for the year, or period, in which the ages were reached. In describing the results of this computation, which are shown in Table 3, it will be convenient to deal with the higher ages first and proceed backward. Since the cohort being studied could be traced on the basis of actual experience only until it had attained age 55 in 1931, it was necessary to assume that the expectation of life at that age according to the life table of 1930-1932, namely 17.9 years for males and 20.2 years for females, represents the average number of years of life that will actually be lived beyond age 55. Although it is likely that future years will show improvement in these figures, as gains are made in controlling diseases of middle life and old age, material improvements are hardly to be expected on the basis of

TABLE 3

Comparison of expectation of life at selected ages with years of life remaining on basis of subsequent mortality experienced by a cohort traced from birth in 1876 in England and Wales

ATTAINED AGE	AGE ATTAINED IN	YEARS OF LIFE REMAINING ON BASIS OF SUBSEQUENT MORTALITY	EXPECTATION OF LIFE IN YEAR OF ATTAINED AGE	LIFE TABLE FROM WHICH EXPECTATION OF LIFE WAS DERIVED	YEARS OF LIFE GAINED BY SUBSEQUENT IMPROVEMENT IN MORTALITY UP TO 1930-32
		Cohort of males			
Birth	1876	46.3	41.4	1871–80	4.9
10	1886	53.7	49.0	1881–90	4.7
20	1896	45.1	41.0	1891–00	4.1
30	1906	37.2	34.8	1901–10	2.4
35	1911	33.3	31.7	1910–12	1.6
45	1921	25.4	25.2	1920–22	.2
55	1931	17.9	17.9	1930–32	0
		Cohort of females			
Birth	1876	50.6	44.6	1871–80	6.0
10	1886	56.9	51.1	1881–90	5.8
20	1896	48.4	43.4	1891–00	5.0
30	1906	40.3	37.4	1901–10	2.9
35	1911	36.3	34.4	1910–12	1.9
45	1921	28.2	27.7	1920–22	.5
55	1931	20.2	20.2	1930–32	0

our present state of knowledge within the next few years through which the cohort being studied must pass. The assumption of a fixed expectation of life for age 55 is therefore essentially admissible and in any case is necessary as a starting point for our computation. It should, of course, be borne in mind in the comparisons about to be presented.

It turns out that the average years of life remaining per survivor on the basis of subsequent mortality when the cohort of males attained

age 45 in 1921 was only .2 years greater than the expectation of life (25.2) at that age according to the current life table of 1921. The difference is less than one percent. Naturally, when the figures for the cohort at its younger ages are examined, the number of years of life gained, over the current expectation of life, by the subsequent improvement in mortality becomes appreciably greater. When the cohort was age 30 in 1906, the expectation of life indicated in the life table for 1901-1910, namely 34.8 years, was almost two and one-half years below the years of life actually remaining. At its birth in 1876, the cohort had an expectation of life of 41.4 years, according to the life table for 1871-1880. Actually, the average length of life for this cohort of males is 46.3 years,[6] or 4.9 years greater than the expectation of life at birth. For the generation of females born in 1876, the gain was even greater, amounting to 6.0 years; in this instance, the average length of life came to 50.6 years while its expectation of life at birth was 44.6 years. The superiority of the females in years of life gained over expectation of life was also manifest at the higher ages. According to this example, the expectation of life at birth would have erred as a measure of longevity by an understatement of 12 percent in the case of males and of 13 percent in the case of females.

"GENERATION" LIFE TABLES FOR AN ENTIRE POPULATION

So far, the example has been concerned only with a single cohort born at one particular point of time and traced from birth to death on the basis of mortality actually experienced. Brief consideration will now be given to a corresponding example for an entire population comprising persons of various ages living at one time. For this purpose, the pertinent facts relating to the population of England and Wales in 1876 are presented in Fig. 2. The details regarding males and females *born in that year* have already been fully described and will not be repeated here. But according to the life table for 1871-1880, which may be used to represent conditions in 1876, males *then alive at age ten* had an expectation of life of 47.6 years. By tracing them forward as a cohort on the basis of the mortality actually experienced, it is found that the average number of years of life remaining to them came to 52.0, or 4.4 years more than their expectation of life. Similarly, males

[6] Allowing, as indicated above, for survival after 1931 according to the mortality rates then prevailing.

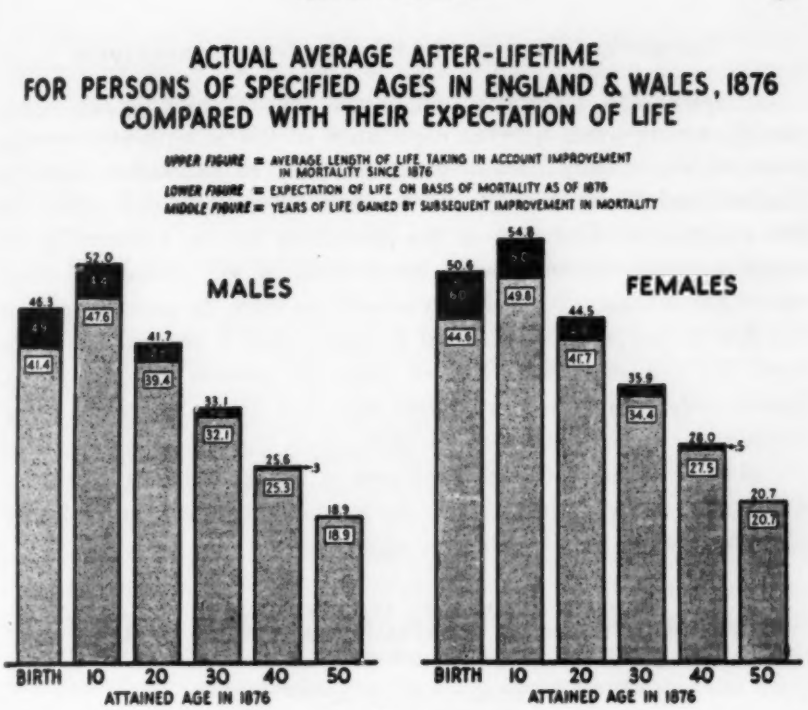

FIG. 2

at age 20 in 1876 had an expectation of life of 39.4 years, but the average after-lifetime remaining was greater by 2.3 years. At age 30, the expectation of life was short by one year, at age 40, by .3 years, and at age 50, it was identical with the average years of life subsequently lived.

The superiority of females over males in increasing their longevity over their current expectation of life is again evident when their corresponding data for various ages are examined. Whereas females who were age ten in 1876 actually lived 5.0 years longer than their expectation of life at that time, males of that age gained only 4.4 years. For those who were age 30 in 1876, the respective gains were 1.5 years and one year, and for those age 50 in that year, there was no gain in either sex. It is thus seen that, not only for the new-born of 1876, but for persons at every stage of life at that time, up to age 50, actual survival has materially exceeded the expectation based on the current life table for that period.

"GENERATION" LIFE TABLES FOR SUCCESSIVE GENERATIONS

1. *After 1876.* There is still another line of investigation open, namely, a comparison between expectation of life at birth and average years of life actually remaining for each of the generations born in England and Wales, in 1876, 1886, 1896, 1906, 1911, and 1921. In this analysis, the limitation of the process of tracing a cohort by its actual mortality becomes more accentuated as we proceed to more recent generations. While it was possible to trace the generation born in 1876 on the basis of its actual mortality until it reached age 55 in 1931, for the generation born in 1886, the process of tracing was feasible only until the cohort attained age 45 in 1931. In corresponding manner, the generations born in 1896, 1906, 1911, and 1921 can be traced by actual mortality only until ages 35, 25, 20, and 10, respectively, are attained in 1931. In each case, the mortality assumed for the higher ages was that of the life table for 1930-1932.

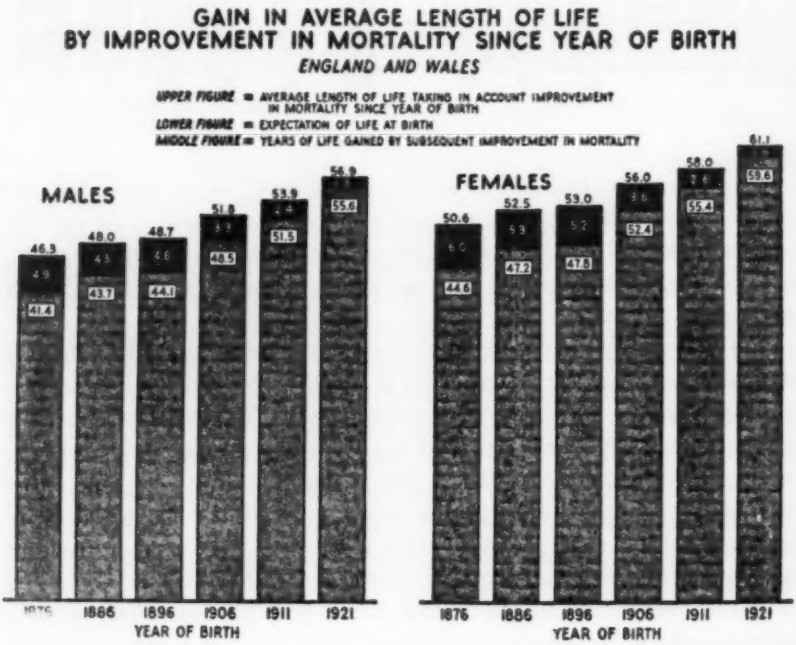

FIG. 3

Despite the limitation imposed for these later cohorts, there is a certain interest in the results, for they indicate a minimum estimate of the gain in actual longevity over expectation of life at birth for each of the successive generations dealt with. They indicate minimum gains because it was assumed that no improvement in mortality occurred in England and Wales after 1931; reports issued since 1931 but prior to the outbreak of war in September, 1939, show reductions in the death rate, but it was not expedient to use this information in the computations.

The results of the computations are shown in Fig. 3. Starting with the generation born in 1921, it is seen that simply by improvement in mortality in the decade following their year of birth, the average length of life of males has been increased by 1.3 years as compared to their expectation of life at birth, while females gained 1.5 years. Similarly, in the generation born in 1911, males will have an average length of life at least 2.4 years greater than their expectation of life at birth and females will gain 2.6 years, and so on for the earlier generations. It must not necessarily be inferred from these figures that the more recent generations will ultimately show smaller excess in their average length of life beyond their expectation at birth than the earlier generations. The more recent generations are still young and have before them many years which will undoubtedly benefit from further diminutions in mortality. Still, it must be admitted that the more recent generations were born in periods of higher expectation of life at birth and further improvements will become increasingly difficult.

Computations corresponding to those for England and Wales were carried out for the generations born in Massachusetts[7] and in the Original Death Registration States in 1901, 1910 and 1919-1920. The results, shown in Fig. 4, are essentially like those found for England and Wales. The improvement in mortality from the time of their birth in Massachusetts in 1890 until they attained age 40 in 1930 netted the generation of males a gain of 4.9 years beyond their expectation of life at birth and the females a gain of 5.1 years. The figures for expectation of life at birth were 42.5 years and 44.5 years respectively. The gains found for babies born in Massachusetts in 1910 are 3.3 years for males and 3.4 years for females. These are somewhat greater

[7] A computation was also made for males and females born in Massachusetts in 1890.

than the figures observed in the Original Death Registration States for 1910 which are 2.6 years for males and 3.0 years for females. However, the latter are not far different from the corresponding figures for children born in England and Wales in 1911, which were 2.4 years for males and 2.6 years for females.

2. *Prior to 1876.* In each of the examples so far cited, a sizable gain in longevity for the generation has been shown over its expectation of life at birth; for the generation born in 1876, as we have seen, the gain was quite considerable. However, it cannot be inferred from these findings that similar gains prevailed for generations born in prior years. To investigate this aspect of the problem, a "generation" life table was prepared for the generation born in England and Wales in 1841. Use was made of the life tables for 1838-1844 and 1838-1854, centered at 1841 and 1846 respectively, in addition to the series of life tables beginning with 1871-1880.[8]

The resulting computation showed that the generation of males born in 1841 had an average length of life of 40.4 years, a figure identical with the expectation of life at birth according to the life table for 1838-1844. For females, the average length of life was 43.5 years, or only 1.5 years more than their expectation of life at birth (42.0 years). In other words, there was either no gain or only a slight gain in longevity over the expectation of life at birth for the generation born in 1841, as compared with the generation born in 1876, which showed a gain of 4.9 years for males and 6.0 for females. This comparison indicates strikingly that improvement in living conditions and progress in public health in the middle of the last century was indeed slow. The public health movement in England and Wales and in the United States began to have its effect upon longevity only in the last quarter of the century, when increasing advantage was taken of the extraordinary discoveries regarding the spread and prevention of disease.

[8] In this computation, it was necessary to interpolate mortality rates for the generation at ages from 5 to 35 between the life table for 1838-1854 (centered at 1846) and that for 1871-1880 (centered at 1876). Although this range of interpolation is rather wide, the method of interpolation (see text) yields mortality rates which are probably not far from the actual at ages near 5 and 35. The margin for error is greatest at the center of the interval from 5 to 35, namely at age 20.

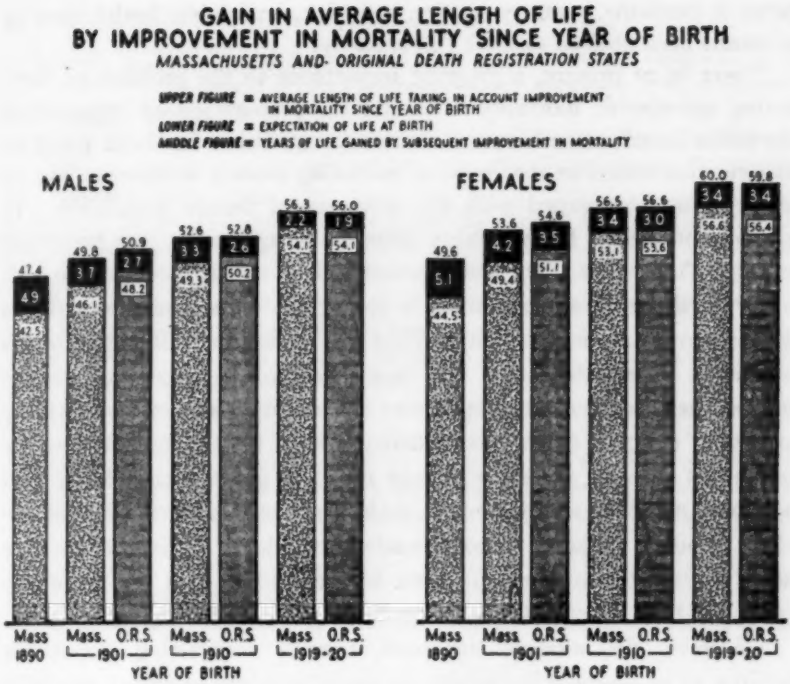

FIG. 4

CONCLUSION

It is evident, from the facts presented above, that the expectation of life at birth, as derived by the usual methods of life table construction, and applied to cohorts living in recent decades, falls short as a measure of the longevity of a generation. In the instance of the generation born in England and Wales in 1876, it was noted that the expectation of life at birth was less than the average length of life based upon the mortality actually experienced, by almost five years for males, and six years for females. However, so great a disparity is not likely to be experienced by generations recently born, although this trend will continue so long as mortality improves. A population cannot, of course, continue indefinitely to outlive its expectation of life at birth; a point will some day be reached characterized by optimum mortality. But there is still ample room for progress; for, the most modern develop-

ments in medicine, sanitary science, nutrition, and public health have by no means been utilized to their full capacity.

There is, at present, a growing importance to the problem of forecasting age-specific mortality rates and the preparation of hypothetical life tables based on such rates. Particular attention has been given by actuaries interested in the trend of mortality among annuitants and by demographers concerned with the estimates of future population. In case of annuitants, the mortality situation is unique in one important respect. As a class, they are concentrated at the advanced ages, and, as far as the general population is concerned, these ages have shown little improvement in mortality within the history of our public health movement. Nevertheless, it has been observed in successive investigations, that the mortality experience on annuity contracts is gradually improving (4,17). Since this tendency toward lower mortality and the consequent increase in longevity may result in greater sums being paid to annuitants than anticipated in their contracts, actuaries find themselves required to adopt a conservative attitude in setting up annuity rates; for what is a source of gain to the insurer in a life insurance policy can be a source of loss in an annuitant's contract.

Likewise, the modern approach toward forecasting population requires, as an essential ingredient, a careful estimate of future mortality at various ages. That these forecasts are matters of more than academic interest was shown quite recently, when practical problems involving future mortality and population arose in connection with the old age insurance provisions of our social security program (18). As a matter of fact, any long range planning by government and by industry will necessarily be built around estimates of our future numbers (19, 20). In any future population policy, important consideration must be given to estimates of population growth (20).

Since the problem of preparing estimates of future mortality is thus an eminently practical one, it is obvious that our available information should be analyzed in all of its aspects. By adding an investigation of the mortality experience of generations traced from birth to our studies of mortality along the more traditional lines, we are perhaps increasing the likelihood that future estimates will be more in harmony with the facts.

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PHYSIQUE IN HEREDITARY MENTAL DEFECT AN ANTHROPOMETRIC STUDY OF 97 'OLD AMERICAN' FEMALE MORONS

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Problem, Material, Technique

THE relation between body and mind is currently receiving increased attention and improved methods of investigation on several different fronts. The broad outlines of the problem have already been marked out; research now should be so constructed as to provide a definite answer to a specific problem, and procedure so standardized as to facilitate subsequent comparisons. Previous studies (1) on the whole indicate that there are undeniable associations of physique with intelligence, that aspect of mind considered here. Their existence and extent have been obscured by the operation of insufficiently controlled but relevant variables. Before somatic differences between normal and defective groups, even when statistically significant, can be deemed associations primarily with intelligence — sex, age, race, and socio-economic status should be controlled; as should the type and severity of defect. Moreover, a range of intelligence should be secured wide enough to disclose a relationship which is apparently neither linear, causal, uniform (in all segments of the intelligence continuum), nor even—for many traits—very close.

Subjects. The defective group consists of 97 'Old American' females between 20.2 and 53.5 years of age (mean age: 29.8 ± .51 years) in State institutions for the feeble-minded in Massachusetts, Connecticut, Rhode Island, and New York. Table 1 shows the geographical distribution of the subjects, all of whom are hereditary morons of the very lowest social class.

An Old American is a person "whose parents as well as all four grandparents were born in this country" (Hrdlička (10)). A moron

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TABLE 1

Geographical distribution of morons

	OLD AMERICANS	(IRISH)
Waverley, Mass.	12	2
Wrentham, Mass.	8	3
Belchertown, Mass.	26	8
Mansfield Depot, Conn.	22	..
Exeter, Rhode Island	1	4
Letchworth Village, N. Y.	28	4
Totals	97	(21)

is an individual whose I. Q. remains between 50 and 70 on successive retestings. As defined for this study, an "hereditary" moron is one in whose family mental deficiency and/or psychosis definitely appears, and for whose defect no other possible etiology has been demonstrated. The former stipulation prevents the "hereditary" from being merely a residual classification (such is another institutional category, the "undifferentiated"); the latter excludes known traumatic and post-infectious cases. The work of Greene (2) and Duncan (3), though Slater (4) disagrees, provides some justification for assuming for this purpose a connection between psychosis and feeble-mindedness. The sample is still further "purified" by the exclusion of psychotics and of persons with any physical affliction, hereditary or acquired, likely to affect the characters studied.

Selection was based on information provided in the institutional case records. Most of the morons are from inbred rural communities and hence considerably exceed the minimum requirements for Old Americanism. Some cases officially diagnosed as "hereditary" defectives were rejected from the study because the evidence was considered insufficient—I. Q. tests, psychiatric diagnoses, and/or institutionalization of relatives were required for this purpose. Thus, defect is present in the subjects' heredity; whether this is actually the cause of their feeble-mindedness cannot be determined. However, three factors favor this view: (1) institutions contain a larger proportion of the hereditary type than occurs among morons in general (Fernald (5)); (2) abnormal

labor and birth trauma, a possible etiology not eliminated by the previous selection, produce idiots and dull normals rather than morons (Dayton (6)), (Findlay (7)); and (3) owing to the recessive nature of the defective genes controlling mental development, inbred rural communities are fertile sources of hereditary feeble-mindedness.

Technique. The standard anthropometric procedure of Hrdlička's manual was employed, with some modifications, after Hooton (8). For head height, no special instrument was used other than the anthropometer as sliding caliper (Howells' "projective" method (9)). The final measurement is the average of the two tragion-vertex readings. This procedure is simple and allows the detection of bilateral asymmetries, of frequent occurrence in defectives.

Controls. Three published series of Old American females were utilized: one by Hrdlička (10) and two by Carter (11). Hereafter, the four series will be designated respectively Morons, Laboratory, POA (Pembroke College), and UTOA (University of Tennessee). Although the 3 normal series satisfy the racial requirement, afford checks on age in both directions, and differ considerably from the Morons in intelligence, social status (especially of the college students) is too high. Accordingly, a fourth normal group (hereafter called C of P) was selected from the females over 20, native-born white of native parentage, who were measured by the Harvard Laboratory at the Chicago 1933 Century of Progress Exposition. These measurements were collected under the direction of Dr. C. W. Dupertuis, who kindly allowed access to the unpublished data.

TABLE 2

Size and age of series

	MORONS	C OF P	LABORATORY	POA	UTOA
Number	97	183	210	109	161
Age in years — mean ± p.e.	29.8±.51	33.2±.48	41.0	19.3	19.3
Age in years — range.....	20.2—53.5	20—58	22—60	16—25	17—25

In the C of P series, Old Americanism was approximated by selecting for surname and (Protestant) religion; low social status, by using educational and occupational data. For example, no one was

admitted who had ever attended college, music school, business school, etc. Both procedures were admittedly imperfect, but represent the best that could be done with the available information. Although the C of P series is not quite as strictly Old American as the others, its age is closer to that of the Morons. The same is true of intelligence and social status, both of which still remain higher. Moreover, all constants can be calculated for this series, enabling the significance of differences to be estimated—this is not always possible for the other controls. And finally, since the Morons and C of P series employed the same anthropometric blank and technique, the latter serves as sole control group for some characters.

It may be noted here that social status affects only certain of the characters studied; and of these some (e.g., head length, bizygomatic diameter, stature, various indices) differ more than can be expected on the basis of social status alone, while others (e.g., chest depth, upper face height, nose height) differ in the opposite direction to that expected on the same basis.

RESULTS

First the Moron constants will be presented; then the Morons will be compared to the normal series in respect to means for separate traits, morphological observations, and variability. In the interests of standardization, the tabular arrangement of Gray and Ayres (12) and of Gray (13) will be followed.

Anthropometry.

Comparison of moron with normal means. With 3 as the level of significance of the Critical Ratio CR (difference/its probable error), the following eight traits *do not differ* as between the Moron and normal series: biacromial diameter, chest breadth, total face height, bigonial diameter, nose breadth; and relative sitting height, cephalic index, and zygo-frontal index.

In *nasal index,* the Morons are significantly lower than two of three control groups, and in *total facial index* significantly higher than three of four controls. For the former index the POA, and for the latter the UTOA mean does not differ from the Moron. Hence, these two indices do not vary solely, if at all, with intelligence.

TABLE 3

Table of constants

Female hereditary morons *Age: 29.8 ± .51 (20-54)* *N:97**
Mass., Conn., R. I., N. Y. *Race: Old American*

MEASUREMENT		MEAN	P.E.	S.D.	P.E.	C.V.	P.E.	RANGE
Weight (lbs.)	W	119.5	1.2	17.8	.86	14.9	.72	86–185
Stature (mm).....	S	1549.9	4.1	59.8	2.90	3.86	.19	1357–1677
Span	Sp	1565.6	5.0	71.9	3.52	4.58	.22	1406–1724
Sitting height.....	Si	830.1	2.12	30.8	1.5	3.71	.18	743–892
Shoulder biacromial..	BA	346.2	1.1	15.9	.77	4.58	.22	308–388
Pelvis bicristal*.....	BC	287.8	1.33	18.5	.94	6.44	.33	254–330
Chest transverse.....	T	267.6	1.2	17.4	.84	6.52	.32	227–318
Ant. post.*.....	AP	222.2	1.61	20.4	1.14	9.20	.51	184–263
Head circumference**	H	536.6	1.28	18.5	.90	3.45	.17	492–626
length.....	L	181.66	.50	7.3	.35	4.02	.20	167–212
breadth	B	143.5	.44	6.4	.31	4.47	.22	131–173
height.....	OH	114.3	.46	6.6	.32	5.8	.28	98–132
Minimum frontal....	MF	100.1	.18	2.54	.12	2.54	.12	90–114
Bigonial diam.....	BG	98.35	.38	5.5	.27	5.64	.27	85–114
Face height.....	MN	113.4	.48	7.04	.34	6.21	.30	94–127
breadth.....	BZ	128.2	.32	4.6	.23	3.62	.18	118–140
Upper face height...	PN	67.92	.32	4.63	.22	6.81	.33	56–80
Nose height.....	NH	51.57	.29	4.24	.21	8.21	.40	39–66
breadth	NB	32.82	.15	2.16	.10	6.58	.32	26–38
Index								
Stature-span	Sp/S	101.17	.22	3.16	.15	3.12	.15	91.2–114
Relative sitting ht....	Si/S	53.61	.92	1.34	.65	2.50	.12	49.9–56.3
Rel. shoulder brd.....	BA/S	22.44	.07	.98	.05	4.38	.21	20.6–26.6
Shoulder-hip*	BC/BA	82.12	.39	5.0	.28	6.07	.34	70.4–93.6
Thoracic*	AP/T	83.39	.53	6.78	.34	8.13	.45	67.7–97.8
Cephalic	B/L	79.02	.23	3.32	.16	4.19	.20	71.1–86.4
Length-height	OH/L	63.0	.24	3.54	.17	5.62	.27	53.8–70.3
Breadth-height	OH/B	79.64	.30	4.38	.21	5.49	.27	68.3–91.0
Fronto-parietal	MF/B	69.55	.23	3.36	.16	4.83	.24	61.3–76.1
Fronto-gonial	BG/MF	98.84	.44	6.35	.31	6.43	.31	85–120
Cephalo-facial	BZ/B	89.57	.22	3.18	.15	3.54	.17	80.3–96.9
Zygo-frontal	MF/BZ	77.81	.22	3.26	.16	4.18	.20	66.7–83.1
Zygo-gonial	BG/BZ	76.53	.27	3.88	.19	5.07	.25	67.0–86.1
Total facial	MN/BZ	88.62	.38	5.54	.27	6.25	.30	73.4–102.5
Upper facial.....	PN/BZ	52.91	.26	3.72	.18	7.04	.34	43.7–63.9
Nasal	NB/NH	62.77	.43	6.30	.31	10.0	.48	46.7–80.0

* For pelvis bicristal and the shoulder-hip index, N = 76. For chest depth and the thoracic index, N = 73.

** Hair did not interfere with the taking of head circumference, inasmuch as the Morons' hair was almost universally straight, fine, and close-cropped.

Table 4 summarizes those differences which are significant between Morons and *all* control groups. (The number of control series varies somewhat from one trait to another.) The differences are grouped in approximate order of increasing magnitude of CR: i.e., the Moron minimum frontal is just significantly smaller than the normal, the head height markedly so; the fronto-gonial index is just significantly larger, the upper facial index markedly so.

TABLE 4

Morons vs. normal series—significant differences of means, arranged in order of increasing magnitude of CR

MORONS SMALLER	NO DIFFERENCE	MORONS LARGER
Minimum frontal	Biacromial diameter	Fronto-gonial index
Weight	Chest breadth	Zygo-gonial index
Bizygomatic	Total face height	Cephalo-facial index
Head length	Bigonial diameter	Stature-span index
Head circumference	Nose breadth	Nose height
Head breadth	Relative sitting height	Fronto-parietal index
Head breadth-height index	Cephalic index	Chest depth
Span	Zygo-frontal index	Upper face height
Head length-height index		Thoracic index
Stature		Upper facial index
Relative shoulder breadth		
Sitting height		
Head height		

Discussion. It will be observed that virtually all the long measurements of the body are significantly smaller in the Morons—*biacromial diameter* and *chest depth* are the exceptions. The general size reduction is noted by all previous investigators; also cf. Hooton (14).

Among the characters showing no difference, the evidence on *relative sitting height* is equivocal. Flory (15) also found no difference, but Doll (16) and Davenport and Martin (17) report that defectives have lower relative sitting heights than is normal. Flory's series and procedure are more comparable to those of the present study. All previous evidence agrees that *cephalic index* is quite independent of intelligence.

The last traits in both "Smaller" and "Larger" columns, showing the greatest differences, warrant further discussion. Flory found that though *chest depth* in mental defectives (all grades and types, undifferentiated racially) is smaller than that in private-school boys (socially and racially selected), idiots, otherwise the worst developed physically of all aments, have deeper chests than morons. The present Moron superiority to the normal in both *chest depth* and *thoracic index* confirms Weisman's (18) assertion of the association between the low, phylogenetically advanced index and intelligence. However, he also notes the negative correlation of the index with social status, which factor may thus account for part of the observed difference. In any case, the notorious uncertainty of the measurement, especially in women, should induce caution in interpretation.

Social status probably influences *head height* as well; Gray and Ayres (19) found extremely high heads in upper-class Old American children. The present technique (*q. v. supra*) would tend, if anything, to *raise* the Moron mean!

The Moron *upper face height* and its *index* differ unexpectedly in both direction and magnitude from the normal. This anomalous position indicates the desirability of multiplying the characters studied rather than concentrating on a few gross measurements, since the Moron and normal series differ not at all in *total face height* and but little in *total facial index*. To determine whether mental status is actually involved, and not merely inbreeding or a fortuitous combination of control groups (though both factors do contribute), comparisons were made between Moron and C of P Irish, both chosen in exactly the same way as the Old Americans. The two Irish series are even more comparable (except, of course, in intelligence) than are the Old American Morons and C of P. Both Irish groups are native-born of foreign parentage. The C of P are 10 years older than the Morons, which if anything would increase their dimension and index.

In *upper face height*, OA Morons are larger than the C of P by 4.52 mm., with CR 11.8; Irish Morons are larger than C of P by 1.69 mm., with CR 2.

In *upper facial index*, OA Morons are larger by 7.47 mm., with CR 24; Irish Morons are larger by 6.64 mm., with CR 10.5.

Though the Irish series are too small to be conclusive, the trend is in the same direction and suggests that mental status is chiefly responsible for the observed differences.

Anthroposcopy. The following 25 morphological traits, of 77 observed, differ as between the Morons and normal series. The C of P series is the sole control group for most of these, inasmuch as Hrdlička includes only a few and Carter none at all. Those differences only are noted which persist after all possible allowance has been made for varying standards; nevertheless, the personal equation is so great that the

TABLE 5

Upper face height and index—morons vs. normal, OA and Irish

		N	MEAN	P.E.	S.D.	P.E.	C.V.	P.E.	RANGE
Upper face height									
OA	Morons	97	67.92	.32	4.63	.22	6.81	.33	56–80
	C of P	183	63.40	.21	4.32	.15	6.81	.24	52–72
Irish	Morons	21	66.05	.79	5.38	.56	8.14	.85	54–72
	C of P	72	64.36	.34	4.25	.26	6.61	.37	55–77
Upper facial index									
OA	Morons	..	52.91	.26	3.72	.18	7.04	.34	43.7–63.9
	C of P	..	45.44	.17	3.40	.12	7.47	.26	37–56
Irish	Morons	..	51.76	.58	3.94	.41	7.60	.79	43.7–57.4
	C of P	..	45.12	.26	3.33	.19	7.38	.42	37.5–56.0

same confidence cannot be placed in the morphological as in the metrical data. In Table 6 "Less" and "Greater" refer of course to percentages falling in the indicated categories, and not to the expression of a trait in individuals. Traits marked with an asterisk (*) show especially great differences.

Discussion. These differences are not exhaustive. Others were found (e.g., more vascularity, less head hair, greater eye obliquity, smaller opening height of eye, greater teeth loss) which may well be significant but which cannot be positively so stated, due to inconclusive evidence.

Gross "stigmata of degeneration" occur only rarely in the Morons. Mild forms of *asymmetry* are very common. Cranial and facial asymmetries are noted in Table 6. The disturbance of the usual associations between *nostril thickness* and *laterality of axes,* and between *upper* and

lower membranous lip thickness may be further instances. So are the high frequency of deviated septa and the cases in which left and right tragia give markedly different head height readings.

Variability. Table 7 shows differences of Moron from normal coefficients of variation. Reading down and from left to right, the traits are listed in order of increasing Moron variability (on basis of

TABLE 6

Morons vs. normal series—Morphological observations

MORONS LESS	MORONS GREATER
Grayness of hair	Paleness of skin
Eyebrow thickness	Left-handedness
Eyebrow concurrency	Fineness of hair
Forehead height	Median eye-folds
Nostril thickness	Forehead slope
Thickness of membranous lower lip, when different from upper	Laterality of nostril axes
Chin prominence*	Thickness of integumental lips
Temporal fullness	Thickness of membranous upper lip
	Lip eversion
	Lip seam
	Midfacial prognathism
	Alveolar prognathism
	Overbite
	Size of ear lobe*
	Cranial asymmetry
	Facial asymmetry
	Linear body build

* Difference especially marked.

CR's) *as compared with normal C. V.'s.* Those traits are classed "not significant" whose coefficients differ from *all* the normal series which include the trait, but with CR's between 1 and 2.9. The direction of difference is unmistakable; the amount, small. As in Table 4, "significant" differences are those with CR 3 or higher between the Morons and *all* control groups for a given trait.

TABLE 7

Morons vs. normal series—Variability

Arranged in order of increasing magnitude of CR

MORONS SMALLER		NO DIFFERENCE	MORONS GREATER	
Minimum frontal	significant	Thoracic index	Span	not significant
Biacromial	significant	Upper face height	Cephalic index	not significant
Chest breadth	not significant	Upper facial index	Nasal index	not significant
Weight	not significant	Sitting height	Head breadth-height index	not significant
Relative sitting height	not significant	Stature	Fronto-parietal index	not significant
Chest depth	not significant	Bizygomatic	Zygo-frontal index	not significant
Relative shoulder breadth	not significant	Cephalo-facial index	Zygo-gonial index	not significant
Nose breadth	not significant		Total facial index	significant
			Bigonial	significant
			Nose height	significant
			Total face height	significant
			Fronto-gonial index	significant
			Stature-span index	significant
			Head breadth	significant
			Head length-height index	significant
			Head height	significant
			Head length	significant

Conclusions from Table 7:

(1) Four of the seven characters under "No Difference" are nevertheless more variable than one or more of the control groups. With, in addition, a great preponderance of traits in the "Greater" column, the Morons are clearly more variable than the normal series. This is partly because they are drawn largely from different inbred rural communities, each with a distinct local physique, a fact which is important also in interpreting certain differences in means. However, this factor cannot account for most of the increased Moron variability, a condition which has been noted in virtually all studies of aments. Cf. Doll (20), Flory (21), Rosenbluth (22), Szondi (23), and Tirapegui (24).

(2) Indices participate more in the increased Moron variability than do absolute measurements, though indices are scattered evenly throughout an arrangement of Moron C. V.'s in order of magnitude.

(3) Head dimensions participate more in the same phenomenon than does any other main cluster of traits, though head dimensions are rather low in variability within the Moron series itself.

SUMMARY

Metric constants are presented for 97 adult female hereditary morons, of Old American descent, in State institutions in Mass., Conn., R. I. and New York. Comparisons are made with four normal series, of similar age, sex and race, three published and one unpublished. Significant differences are found as follows:

1. The morons are smaller in most of the measurements of the body, especially the long ones. Chest depth and upper face height, two exceptions, are discussed more fully; the latter, with additional Irish subjects introduced.

2. Morphologically, "stigmata of degeneration" are found, but not in the grosser forms: low, sloping forehead, strong prognathism, receding chin, narrow temporals, marked asymmetry. Interestingly enough, the ear is not greatly affected, only the lobe size differing from the normal. Lips are thick; hair development is weak; linear body build predominates greatly over the lateral.

3. Morons are more variable than normal groups, especially in indices and head dimensions.

These three sets of results accord with the trend of evidence in the literature and are especially valuable in implementing statistically what have too often been unstandardized treatments of heterogeneous series. "The rationale for the associations shown between body and mind cannot unfortunately be proven at present. Nevertheless, the measurements as condensed and tabulated are worth putting on record, and also offer some aid in differential diagnosis" (Gray (25)). If sufficient detailed studies are made of normal and abnormal groups of different sex, age, race, social status, and type of defect, the true associations between physique and intellect will be discernible, and the problem of causation can then be attacked.

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ANATOMIC LAG IN HEAD AND BODY DIMENSIONS[1]

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IN previous articles the writer has pointed out that when two dimensions of the body are positively correlated it is usually found that they do not increase at the same rate but at a differential rate, that is to say, one lags upon the other. This phenomenon we have designated anatomic lag.[2] The manner of determining the character and the amount of lag has been dictated by the character of the available data. When paired dimensions are given we have correlated them, computed the relative regressions, that is, r_{xy} $(\sigma x/\sigma y)$ and r_{yx} $(\sigma y/\sigma x)$ and the ratio $(\times 100)$ of these relative regressions. If the two dimensions increase at the same rate, the ratio will be 100. When one dimension can not be compared directly with another, but an index is available, of which that dimension is a component, we have correlated the dimension with the index. The computed correlation coefficients and regressions indicate the character of the lag, but not the ratio of the lags. When each of two paired dimensions is expressed as a fraction of the same dimension, for example, arm length/stature and leg length/stature, the correlations and regressions express the character of the lag, but not the ratio. When indices are correlated, or a dimension and an index, the regressions are in terms of sigmas. When dimensions are correlated, the regressions are in terms of coefficients of variation. A positive correlation of x with x/y

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[2] See Wilson D. Wallis, Anatomic Lag, HUMAN BIOLOGY, 6: 524-542, 1934, and *Child Development*, 9:87-121, 1938.

indicates lag of y on x; a negative correlation indicates acceleration of y on x; conversely, a positive correlation of x with y/x indicates acceleration of y on x, and a negative correlation indicates lag of y on x. When dimensions are positively correlated the degree of lag is inversely related to the magnitude of the regression; when they are negatively correlated, the degree of lag is in direct proportion to the magnitude of the regression; and the ratios are interpreted accordingly.

When means of groups are paired, nasal height is negatively correlated with basi-bregmatic height, and the lag is much greater in the former than in the latter. Cranial breadth lags less on cranial height and cranial horizontal circumference than do the latter two on cranial breadth. Face breadth lags less on mandible width than conversely, in means of groups, and less on orbital breadth than conversely. The lags of head breadth and head length on one another are indicated by the positive correlations of head breadth with cephalic index, and the negative correlations of head length with that index. In means of Indian tribes, menton-nasion diameter lags more on nose length than the latter on the former.

Means of ethnic groups, when correlated, do not always show the same type of differential in lags of paired dimensions which characterize a series of individuals, though in most instances they do so, for example, in negative correlation of nose height with nose index.

Body dimensions show lags comparable with those that characterize dimenions of head or skull. Nasal breadth and nasal length lag less on span, than span on either of them. Lag of cephalic breadth on stature is greater than lag of stature on cephalic breadth. For means of groups, there is often a negative correlation of these two dimensions. In means of Swedes, stature and face breadth are negatively correlated, and face breadth lags more on stature than stature on face breadth.

In four series stature lags on head circumference less than the converse, and in two series it shows greater lag. In 24 series stature shows less lag on head length than the converse, and in 11 series it shows greater lag on head length than conversely. Stature lags more on humerus length than humerus length on stature, and in two of four series humerus length is accelerated on stature. In most series, stature lags more on sitting height and on span than conversely.

TABLE 1. *Lag in head and skull dimensions*

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Basi-bregmatic height	Basi-bregmatic height/Length	Rumanians, Means	M	S	18	.50	.53	.48	...
		Ethnic group, Means	M	S	12	.78	.88	.69	...
		Ethnic group, Means	F	S	10	.85	.82	.89	...
Basi-bregmatic height	Breadth/Basi-bregmatic height	Egyptians, and East Indians, Means	M	S	11	—.30	—.14	—.64	...
Basi-bregmatic height	Breadth/Basi-bregmatic height	Ancient Egyptians, Means	M	S	9	—.63	—.42	—.93	...
Basi-bregmatic height	Breadth/Basi-bregmatic height	Ancient Egyptians, Means	F	S	6	—.37	—.17	—.83	...
Basi-bregmatic height	Breadth/Basi-bregmatic height	India, Means	M	S	9	—.56	—.54	—.58	...
Basi-bregmatic height	Nasal height	Ancient Egyptians, Means	M	S	9	—.04	—.01	—.15	7
		Ancient Egyptians, Means	F	S	6	—.21	—.04	—1.20	3
		India, Means	M	S	9	.50	.28	.90	21
Basi-bregmatic height/Length	Cranial length	Asiatics, Means	M	S	8	—.74	—.67	—.81	...

TABLE 1 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Cephalic breadth	Cephalic index	English (Flamborough)	M	L	73	.56	.47	.68	...
		English (Flamborough)	F	L	17	.65	.43	.99	...
Cranial breadth	Min. frontal br.	Torres Straits	F	S	19	.55	.55	.54	102
		Torres Straits	M	S	18	.74	1.03	.53	193
Cranial breadth	Transverse fronto-parietal index	White patients, St. Louis Children's Hospital							
		Age 7 wks.–12 mos.	F	L	27	.04	.12	.02	...
		13 mos.–24 mos.	F	L	16	.28	.30	.27	...
		26 mos.–4 yrs.	F	L	10	.20	.11	.37	...
		4½ yrs.–6 yrs.	F	L	14	.04	.01	.10	...
		7 yrs.–9 yrs.	F	L	12	.60	.58	.61	...
		10 yrs.–12 yrs.	F	L	18	—.34	—.32	—.36	...
		13 yrs.–14 yrs.	F	L	9	—.54	—.99	—.30	...
		1 wk.–12 mos.	M	L	40	—.11	—.31	—.04	...
		13 mos.–24 mos.	M	L	17	.29	.50	.17	...
		25 mos.–4 yrs.	M	L	12	.28	.56	.14	...
		4½ yrs.–6 yrs.	M	L	14	.04	.07	.02	...
		6.10 yrs.–9 yrs.	M	L	14	—.62	—.79	—.49	...
		10 yrs.–12 yrs.	M	L	18	—.54	—.87	—.33	...
		13 yrs.–14 yrs.	M	L	15	—.30	—.32	—.28	...

Cranial breadth	Cranial height	Torres Straits	F	S	19	.02	.04	.01	312
		Torres Straits	M	S	18	.61	.89	.42	212
Cranial breadth	Cranial circ., horizontal	Torres Straits	F	S	19	.58	.74	.45	164
		Torres Straits	M	S	18	.32	.64	.16	400
Cranial breadth	Cranial length	Torres Straits	F	S	19	.58	.28	1.21	23
		Torres Straits	M	S	18	.61	.45	.83	54
		English (Flamborough)	M	L	73	.54	.60	.48	123
		English (Flamborough)	F	L	17	.47	.58	.39	148
Cranial breadth	Cranial length	Southeastern Europeans, Means	M	L	21	—.39	—.51	—.30	170
Cranial breadth	Inter-stephanic br.	Torres Straits	F	S	19	.64	.64	.63	102
		Torres Straits	M	S	18	.86	.94	.78	122
Cranial height	Cranial circ., horizontal	Torres Straits	F	S	19	.34	.25	.47	53
		Torres Straits	M	S	18	.24	.33	.17	188
Cranial height	Cranial length	Torres Straits	F	S	19	.50	.14	1.86	8
		Torres Straits	M	S	18	.58	.29	1.14	25
		English cadavers, age 20–46	M	S	57	.56	.60	.52	114
Cranial height	Cranial frontal breadth, min.	Torres Straits	F	S	19	.39	.22	.67	33
		Torres Straits	M	S	18	.69	.66	.72	91
Cranial height	Inter-stephanic br.	Torres Straits	F	S	19	.33	.19	.58	33
		Torres Straits	M	S	18	.64	.49	.85	57

TABLE 1 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Cranial circ., horizontal	Cranial length	Torres Straits	F	S	19	.90	.34	2.41	14
		Torres Straits	M	S	18	.74	.27	2.02	13
Cranial circ., horizontal	Min. frontal br.	Torres Straits	F	S	19	.61	.48	.77	62
		Torres Straits	M	S	18	.29	.20	.42	48
Cranial circ. horizontal	Inter-stephanic br.	Torres Straits	F	S	19	.71	.56	.90	62
		Torres Straits	M	S	18	.30	.17	.55	31
Cranial length	Inter-stephanic br.	Torres Straits	F	S	19	.80	1.69	.38	455
		Torres Straits	M	S	18	.72	1.08	.48	228
Cranial length	Height/Length index	Indians (Madisonville Ohio Mound)	M	S	39	—.62	—1.53	—.25	...
Cranial length	Min. frontal br.	Torres Straits	F	S	19	.80	1.69	.38	448
		Torres Straits	M	S	18	.61	1.15	.32	356
Cranial length	Height/Length	English criminals	M	L	130	—.13	—.21	—.09	...
Cranial index	Cranial length	Early British, Means	M	S	8	—.89	—.70	—1.15	...
		Early British, Means	F	S	6	—.90	—1.83	—.44	...

Cranial index	Cranial length	English criminals	M	L	130	—.51	—.29	—.91	...
		Egyptians and English, Means	M	S	6	—.64	—.40	—1.04	...
		English (Flamborough)	M	L	73	—.39	—.41	—.37	...
		English (Flamborough)	F	L	17	—.25	—.37	—.17	...
		Mediterraneans, Means	M	S	14	—.82	—.53	—1.28	...
		Adult Egyptians and Nubians, Means	M	L	20	—.81	—.75	—.88	...
		Scots	F	S	18	—.81	—.49	—1.34	...
		Scots	M	S	37	.59	—.37	—.95	...
		Egyptians (Nubians), Means	M	L	6	—.84	—.92	—.77	...
		Egyptians (Nubians), Means	M	L	6	.84	.31	.23	...
		Russians, Means	F	L	32	—.56	—.39	—.82	...
		African Negroes, Means	M	S	8	—.60	—.38	—.94	...
		Early Mediterraneans, Means	M	S	6	—.76	—.42	—1.40	...
		Indians (Madisonville, Ohio Mound)	M	S	43	—.50	—.31	—.82	...
		Asiatics, Means	M	S	8	.68	1.25	.37	...
		English cadavers, Age 20–46	M	S	57	—.16	—.09	—.27	...
		Ethnic group, Means	M	S	10	—.66	—.59	—.74	...
		Eastern Asiatics, Means	M	S	12	—.93	—1.32	—.66	...

TABLE 1 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Face breadth	Face index	Dyak	M	S	34	—.47	—.43	—.50	...
		Andamanese	F	S	10	—.25	—.32	—.18	...
		Bantam, Java	M	S	19	—.50	—.38	—.65	...
		Middle Java, Means	M	S	30	—.37	—.44	—.31	...
		Andamanese, Means	M	S	20	.09	.06	.12	...
		Tagal (Philippines)	M	S	22	—.67	—1.03	—.43	...
		Tagal	F	S	17	—.86	—.61	—1.22	...
		Aetas (Philippines)	M	S	25	—.72	—.88	—.58	...
		Aetas	F	S	10	—.57	—.49	—.66	...
		Java	M	S	35	—.40	—.31	—.51	...
Face breadth	Mandible width	Norwegian recruits, Means	M	L	20	.91	.95	.87	110
Face breadth	Orbital breadth, right	Middle Java, Means	M	S	30	.50	.56	.45	124
		Andamanese, Means	M	S	20	—.21	—.24	—.18	133
		Tagal (Philippines)	M	S	22	.52	.88	.30	290
		Tagal	F	S	17	—.05	—.10	—.03	344
		Aetas (Philippines)	M	S	25	.29	.35	.25	142
		Aetas	F	S	10	.60	.68	.52	129
		Java	M	S	35	.44	.61	.32	191
Morphological face height	Face breadth	Norwegian recruits, Means	M	L	20	—.17	—.26	—.12	223

Morphological face height	Morphological face index	Semang and Sakai of the Malay Peninsula, Means	MF	L	11	.58	.93	.37	...
Morphological face height	Mandible width	Norwegian recruits, Means	M	L	20	—.22	—.34	—.14	246
Face length	Bizygomatic breadth	Pamirs, Means	M	L	14	—.20	—.11	—.38	28
Upper face length	Head circumference	Pamirs, Means	M	L	14	.19	.46	.08	165
Inter-stephanic br.	Min. frontal br.	Torres Straits	F	S	19	.87	.88	.87	100
		Torres Straits	M	S	18	.84	1.06	.67	159
Head breadth	Biorbital width	Rumanians, Means	M	L	16	.32	.31	.33	96
Head breadth	Head length	Pamirs, Means	M	L	14	—.71	—1.76	—.29	625
Head length	Height/Length	Scots	M	S	35	—.48	—.77	—.30	...
		African Negroes, Means	M	S	8	—.34	—.74	—.16	...
		Early Mediterraneans, Means		S	6	—.86	—1.55	—.47	...
Length of mandible	Mandibular index	Chinese	M	S	39	—.78	—.76	—.79	...
		English	M	S	31	—.27	—.24	—.31	...
		Badarian	M	S	30	—.45	—.20	—1.01	...
		Egyptians	F	S	22	—.55	—.56	—.53	...
		Egyptians	M	S	33	—.58	—.52	—.64	...
		Tamil	M	S	33	—.74	—.55	—.99	...
		Hokien	M	S	38	—.71	—.43	—1.19	...
		Badamian	F	S	19	—.82	—.36	—1.90	...
Menton-nasion height	Nose length	Indian tribes, Means	F	L	21	.59	.49	.72	68
		Indian tribes, Means	M	L	32	.73	.64	.83	78

TABLE 1 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Nose breadth	Nose length	Serbs, Means	M	L	11	.81	.47	1.39	34
		Rumanians, Means	M	S	18	.15	.16	.14	116
		Taze, Means	M	L	15	.20	.16	.26	62
		Balkans, Means	M	L	14	.09	.06	.13	47
		Albanians, Means	M	L	11	.60	.45	.80	56
		Greeks, Means	M	L	13	.66	.69	.62	111
		Jews, Means	M	L	8	—.00	—.00	—.00	526
		Bulgarians, Means	M	L	20	.11	.10	.13	71
		Pamirs, Means	M	L	14	.05	.10	.02	434
		Gypsies, Means	M	L	8	.74	.40	1.38	29
		Turks, Means	M	L	20	—.12	—.13	—.11	120
		Tartars, Means	M	L	22	.33	.33	.33	100
		Dobroudjiens, Means	M	S	15	.39	.48	.32	149
		Kagord (Nigeria), Means	M	L	30	—.11	—.07	—.18	40
		American and African Negroes, Means	M	L	10	—.04	—.03	—.06	51
		American and African Negroes, Means	F	L	5	.42	.52	.34	152
		Malay	M	L	20	.23	.59	.09	667
		Turkestan, Pamirs, Chinese } Means	M	L	25	—.45	—.52	—.40	130
		Egyptians, Means	M	L	7	—.67	—1.18	—.38	312
		Nigeria Negroes	M	L	30	.13	.11	.16	69

		Nigeria Negroes	M	L	30	.13	.11	.16	69
Nose breadth	Nose index	American and African Negroes, Means	M	L	10	.60	.18	2.06	...
		American and African Negroes, Means	F	L	5	.65	.31	1.38	...
Nose height	Nose index	English	F	S	80	—.48	—.26	—.88	...
		Farrington Street	M	S	81	—.49	—.32	—.74	...
		English	M	S	95	—.61	—.46	—.80	...
		Negroes (Kenya)	F	S	42	—.59	—.29	—1.17	...
		Asiatics, Means	M	S	8	—.69	—.65	—.73	...
		Indians (Madisonville Ohio Mound)	M	S	29	—.20	—.20	—.20	...
		Farrington Street	F	S	79	—.42	—.27	—.67	...
		Ancient Egyptians, Means	M	S	9	—.90	—1.16	—.71	...
		Ancient Egyptians, Means	F	S	6	—.52	—.51	—.52	...
		India, Means	M	S	9	—.65	—.54	—.79	...
		Basques, Means	M	S	33	—.69	—.63	—.76	...
		American and African Negroes, Means	M	L	10	—.82	—.62	—1.08	...
		American and African Negroes, Means	F	L	5	—.42	—.28	—.61	...
		Eastern Asiatics, Means	M	S	7	—.90	—.39	—2.08	...

TABLE 1 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Nose height	Orbital breadth, right	Basques, Means	M	S	33	.61	.94	.40	238
Nose height	Palate length	Asiatics, Means	M	S	8	.40	.50	.32	156
Nasion-basion	Sagittal arc	Ethnic group, Means	MF	S	6	—.55	—.11	—2.79	4
Ophryon-alveolar diameter	Ophryon-menton diameter	Rumanians, Means	M	L	16	.56	.54	.57	95
		Gypsies, Means	M	L	8	.95	.71	1.28	55
		Albanians, Means	M	L	11	.93	1.45	.60	242
		Rumanians, Means	M	L	16	.95	1.02	.88	116
Orbital breadth	Orbital index	Tibetans	M	S	32	—.44	—.18	—1.08	...
		Arikara	M	S	43	—.02	—.00	—.88	...
		Indians (California), Means	F	S	10	—.07	—.02	—.33	...
		Indians (Santa Cruz)	M	S	65	—.20	—.01	—5.95	...
		Indians (North Dakota)	M	S	11	—.28	—.01	—8.25	...
		Indians (Santa Barbara)	M	S	44	—.27	—.01	—8.77	...
		Indians (Oglala Sioux)		S	14	—.29	—.01	—7.81	...
		Indians (Brulé Sioux)	M	S	15	—.38	—.02	—9.41	...
		Indians (Iroquois)	M	S	23	—.37	—.02	—9.13	...
		Indians (San Francisco Bay)	M	S	27	—.57	—.02	—18.80	...

Orbital breadth	Orbital index	Indians (Shoshonean)	M	S	11	—.57	—.02	—13.90	...
		Indians (Santa Rosa)	M	S	21	—.48	—.02	—12.63	...
		Indians (Ponca)	M	S	11	—.71	—.02	—22.64	...
		Indians (Shoshonean)	M	S	10	—.51	—.02	—1.71	...
		Indians (San Nicholas)	M	S	10	—.68	—.24	—1.98	...
		Indians (Algonkins and Iroquois)	M	S	11	—.69	—.02	—21.17	...
		Indians (Illinois and Algonkins)	M	S	20	—.15	—.01	—3.50	...
		Indians (N.Y. State)	M	S	11	.21	.04	5.65	...
		Indians (Algonkins, Virginia)	M	S	15	—.05	—.00	—.78	...
		Indians (Massachusetts)	M	S	10	—.40	—.02	—9.35	...
		Indians (Sioux)	M	S	11	—.11	—.00	—4.36	...
		Indians (Cheyenne)	M	S	12	—.26	—.01	—6.56	...
		Negroes (Kenya)	F	S	49	—.28	—.09	—.83	...
		Burmese	M	S	56	—.51	—.17	—1.53	...
		Burmese	F	S	64	—.42	—.13	—1.26	...
		Andamanese	F	S	13	—.46	—.18	—1.18	...
		Dyak	M	S	41	—.36	—.15	—.85	...
		Bantam, Java	M	S	22	—.25	—.11	—.54	...
		Ethnic group, Means	M	S	16	—.44	—.17	—1.15	...

TABLE 1 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Orbital breadth	Orbital index	Ethnic group, Means	F	S	11	—.54	—.20	—1.48	...
		Europeans and Ancient Egyptians, Means	M	S	6	—.37	—.05	—2.54	...
		Indians (Kentucky)	M	S	27	—.54	—.12	—2.45	...
		Anglo-Saxons	M	S	19	—.38	—.12	—1.21	...
		Anglo-Saxons	F	S	23	—.32	—.08	—1.21	...
Orbital breadth, left	Orbital index	Gaboon (Fernando Po)	M	S	18	—.47	—.12	—1.87	...
		Gaboon (Fernando Po)	F	S	19	—.56	—.22	—1.43	...
		Gaboon (Negro)	M	S	50	—.39	—.11	—1.45	...
		Congo (Negro)	F	S	26	—.13	—.05	—.31	...
		Congo (Negro)	M	S	47	—.09	—.03	—.31	...
		Gaboon (Negro)	F	S	43	—.39	—.15	—1.03	...
Orbital breadth, right	Orbital index	Middle Java, Means	M	S	30	—.51	—.23	—1.14	...
		Andamanese	M	S	20	—.52	—.13	—2.06	...
		Basques, Means	M	S	33	—.35	—.12	—1.01	...
		Tagal (Philippines)	M	S	22	—.36	—.12	—1.05	...
		Tagal (Philippines)	F	S	17	—.34	—.13	—.89	...
		Aetas (Philippines)	M	S	25	—.40	—.19	—.85	...
		Aetas	F	S	10	—.55	—.15	—2.02	...
		English (17th century)	M	S	69	.72	.36	1.45	...
		English (17th century)	F	S	62	.63	.22	1.82	...
		Java	M	S	35	—.48	—.18	—1.30	...

Palate height-length index	Palate length	Philippines, Means	M	S	6	—.56	—.19	—1.64	...
Palate length	Palatal index	Ethnic group, Means	M	S	14	—.32	—.38	—.26	...
		Ethnic group, Means	F	S	9	—.48	—.88	—.26	...
		Andamanese	M	S	11	—.70	—.75	—.53	...
		Andamanese	F	S	12	—.75	—.78	—.58	...
		Anglo-Saxons	F	S	12	—.83	—.76	—.63	...
		Anglo-Saxons	M	S	18	—.32	—.53	—.17	...
		Moriori	MF	S	59	—.32	—.69	—.22	...
		Naga	M	S	17	—.70	—.34	—.24	...
		Naga	F	S	9	—.84	—.45	—1.84	...
		Asiatics, Means	M	S	8	—.76	—.30	—1.92	...
		Gaboon (Fernando Po)	M	S	7	—.17	—.08	—.35	...
		Gaboon (Fernando Po)	F	S	9	—.73	—.45	—1.20	...
		Gaboon (Negro)	M	S	33	—.51	—.26	—.99	...
		Congo (Negro)	F	S	17	—.60	—.38	—.96	...
		Philippines, Means	M	S	6	—.58	—.09	—3.70	...
		Congo (Negro)	M	S	30	—.34	—.24	—.47	...
		Gaboon (Negro)	F	S	30	—.34	—.23	—.49	...
		English (17th century)	M	S	62	—.37	—.14	—.96	...
		English (17th century)	F	S	51	—.52	—.23	—1.16	...

TABLE 2. *Lag in body dimensions*

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Arm length	Arm/Stature	Peruvians	MF	L	7	.92	3.63	.23	...
		Nicobarese	M	L	14	.62	1.15	.33	...
		Nicobarese	M	L	36	.71	.75	.67	...
		Andamanese	M	L	48	.80	1.14	.56	...
		Andamanese	F	L	41	.68	1.06	.43	...
		Swedes, Means	M	L	25	.38	6.58	.02	...
		French criminals	M	L	20	.92	.91	.92	...
Arm length	Leg length	Swedes, Means	M	L	17	.55	.61	.49	124
Arm length	Span	Nicobarese	M	L	14	.68	1.02	.45	222
		Nicobarese	M	L	36	.77	.76	.78	98
Arm length/Stature	Leg length/Stature	Russians (before the famine), Means	F	L	17	.01	.01	.02	...
		Russians (before the famine), Means	M	L	18	.21	.21	.20	...
		Russians (after the famine), Means	F	L	17	.02	.02	.02	...
		Russians (after the famine), Means	M	L	18	.13	.09	.19	...
Arm length/Stature	Thoracic cir./Stature	Russians (before the famine), Means	M	L	18	.14	.09	.22	...
		Russians (after the famine), Means	M	L	18	.22	.01	4.07	...

Arm length/Stature	Trunk/Stature	Russians (before the famine), Means	M	L	18	—.69	—.52	—.92	...
		Russians (after the famine), Means	M	L	18	—.59	—.20	—1.80	...
Biacromial diameter	Stature	Swedes, Means	M	L	17	.06	.14	.03	466
Biacromial diameter	Biacromial dia./ Stature	Ethnic group, Means	M	L	10	.96	18.95	.05	...
Biacromial dia./Stature	Pelvic width/Stature	Africans, Means	M	L	13	—.22	—.34	—.14	...
Bizygomatic dia., maximum	Bizygomatic dia./ Stature	Pueblo tribes, Means	M	L	11	.40	.56	.29	...
Chest circumference	Chest cir./Stature	Asiatics (Mongoloid)	MF	L	13	.94	14.34	.06	...
Chin-hair line height	Chin-hair line dia./Stature	Pueblo Indians, Means	M	L	11	.74	1.08	.50	...
Chin-nasion diameter	Chin-nasion dia./ Stature	Pueblo tribes, Means	M	L	11	.80	1.27	.50	...
Cranial length	Length of left cubit	Egyptians and Nubians, Means	M	L	20	.50	.18	1.41	13
Cranial length	Length of left foot	Adult Egyptians and Nubians, Means	M	L	20	.52	.34	.80	42
Cranial length	Foot length	Negritos, Zambales	M	L	16	.11	.07	.17	41
Cranial length	Length of left middle finger	Adult Egyptians and Nubians, Means	M	L	20	.47	.24	.90	27
Length of left cubit	Length of left middle finger	Adult Egyptians and Nubians, Means	M	L	20	.89	1.30	.61	211
Length of left cubit	Length of left foot	Adult Egyptians and Nubians, Means	M	L	20	.53	.97	.29	330
Length of left cubit	Stature	Adult Egyptians and Nubians, Means	M	L	20	.53	.87	.33	263

TABLE 2 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Face breadth	Face breadth/Stature	Indians (S.W. U. S. and N. Mexico), Means	M	L	25	.34	.80	.14	...
Total face height	Total face height/ Stature	Indians (S.W. U. S. and N. Mexico), Means	M	L	25	.24	.53	.11	...
Upper face height	Upper face height/ Stature	Indians (S.W. U. S. and N. Mexico), Means	M	L	24	.44	1.11	1.71	...
Femur length	Humerus length	Giants, Stature 2023-2364	M	L	12	.82	.83	.81	102
Femur length	Radius length	Giants, Stature 2023-2364	M	L	12	.80	.62	1.04	60
Femur length	Tibia length	Giants, Stature 2023-2364	M	L	12	.91	.74	1.11	67
Length of left foot	Length of left middle finger	Adult Egyptians and Nubians, Means	M	L	20	.75	.60	.94	64
Humero-femoral index, right	Humerus length, right	Whites, Means	F	L	7	—.78	—.85	—.72	...
		Whites, Means	M	L	7	.19	.22	.17	...
Humerus length	Radius length	Giants, Stature 2023-2364	M	L	12	.86	.66	1.13	59

Humerus length	Scapula breadth	French, Means	F	L	7	—.06	—.05	—.06	82
		French, Means	M	L	8	—.02	—.10	—.00	...
		French, Means	F	L	7	.67	1.21	.38	322
		French, Means	M	L	8	.38	.27	.53	51
Humerus length	Scapular supraspinal height	French, Means	F	L	7	.88	.09	8.27	1
		French, Means	M	L	8	—.19	—.16	—.23	71
		French, Means	F	L	7	.61	.50	.74	68
		French, Means	M	L	8	—.20	—.11	—.37	29
Humerus length	Tibia length	Giants, Stature 2023-2364	M	L	12	.87	.70	1.07	65
Humerus length, right	Radio-humeral index	Whites, Means	F	L	7	.10	.03	.34	...
		Whites, Means	M	L	7	—.45	—.11	—1.84	...
Humerus/Stature	Radius/Stature	African tribes, Means	M	L	13	.44	.32	.62	...
Illiac diameter	Iliac diameter/Stature	Ethnic group, Means	M	L	10	.92	12.22	.07	...
Intermembral index	Leg length	New Guinea	M	L	5	.36	42.03	.00	...
Knee height	Knee height/Stature	Europeans, Means	M	L	8	.69	2.93	.16	...
Leg length	Leg length/Stature	Turks, Means	M	L	20	.83	39.91	.02	...
		Europeans, Means	M	L	8	.90	.66	.12	...
		Peruvians, Means	MF	L	7	—.19	—4.53	—.01	...
Leg length/Stature	Foot length/Stature	African tribes, Means	M	L	13	—.12	—.48	—.03	...
Leg length/Stature	Thoracic cir./Stature	Russians (before the famine), Means	M	L	18	—.62	—.40	—.95	...
		Russians (after the famine), Means	M	L	18	—.49	—.39	—.60	...
Leg length/Stature	Trunk/Stature	Russians (before the famine), Means	M	L	18	—.30	—.22	—.40	...
		Russians (after the famine), Means	M	L	18	—.30	—.15	—.61	...

TABLE 2 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Nasal breadth	Span	Kagoro	M	L	30	.04	.06	.03	162
		Nigeria Negroes	M	L	30	.24	.25	.24	103
Nasal length	Span	Kagoro	M	L	30	.33	.66	.16	405
		Nigeria Negroes	M	L	30	.49	.60	.40	149
Nasion-crinion	Nasion-crinion/ Stature	Indians (S.W. U.S. and N. Mexico), Means	F	L	27	.92	1.38	.62	...
		Indians (S.W. U.S. and N. Mexico), Means	M	L	40	.93	1.43	.61	...
Transverse pelvic diameter	Transverse pelvic diameter/Stature	Europeans, Means	M	L	8	.45	1.13	.18	...
Pubic height	Pubic index	Europeans, Means	M	L	8	.67	2.60	.17	...
Radius length	Tibia length	Giants, Stature 2023-2364	M	L	12	.89	.93	.84	111
Scapula breadth	Fossa-spinal index	French, Means	F	L	7	—.09	—.02	—.40	...
		French, Means	M	L	8	—.30	—.11	—.84	...
		French, Means	F	L	7	.82	.44	1.53	...
		French, Means	M	L	8	.38	.24	.58	...
Scapula breadth	Infraspinal index	French, Means	F	L	7	—.54	—.21	—1.39	...
		French, Means	M	L	8	—.56	—.31	—.99	...
		French, Means	F	L	7	—.85	—.24	—3.03	...
		French, Means	M	L	8	—.71	—.22	—2.30	...
Scapula breadth	Supraspinal index (Scapula)	French, Means	F	L	7	—.27	—.06	—1.13	...
		French, Means	M	L	8	—.49	—.19	—1.26	...
		French, Means	F	L	7	.48	.63	.36	...
		French, Means	M	L	8	—.32	—.55	—.19	...

		French, Means	M	L	8	—.32	—.55	—.19	...
Scapula breadth	Scapular index	French, Means	F	L	7	.67	.41	1.09	...
		French, Means	M	L	8	.87	.78	.97	...
		French, Means	F	L	7	.83	.57	1.21	...
		French, Means	M	L	8	.75	.60	.94	...
Shoulder breadth	Shoulder breadth/ Stature	Europeans, Means	M	L	8	.51	.38	.67	58
Sitting height	Sitting height/ Stature	Mainly U.S. soldiers, Means	M	L	9	.09	3.74	.00	...
		Groups of mankind (1500-1595), Means	F	L	34	.52	7.45	.04	...
		Groups of mankind (1512-1598), Means	M	L	55	.80	15.96	.04	...
		Groups of mankind (1600-1698), Means	M	L	113	.67	10.57	.04	...
		Groups of mankind (1700-1785), Means	M	L	35	.84	17.21	.04	...
Sitting height	Span	Norwegian recruits, Means	M	L	20	.44	.30	.66	46
Span	Span/Stature	Greeks, Means	M	L	13	—.53	—14.6	—2.07	...
		Turks (Osmanli), Means	M	L	20	.31	18.6	.00	...
		Serbs, Means	M	L	11	.18	20.1	.00	...
		Bulgarians, Means	M	L	20	—.17	—16.2	—.00	...
		Europeans, Means	M	L	8	.07	.23	.02	...
Stature	Chest/Stature	U.S. Troops, Means	M	L	49	—.68	—.07	—6.30	...

TABLE 2 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Stature	Arm length/Stature	Russians (before the famine), Means	F	L	17	.30	14.92	.01	...
		Russians (before the famine), Means	M	L	18	.67	17.26	.02	...
		Russians (after the famine), Means	F	L	17	.52	29.44	.01	...
		Russians (after the famine), Means	M	L	18	.66	32.02	.01	...
		Peruvians (Cuzco and Apurimac)	M	L	140	.06	3.05	.00	...
		Lolos (Chinese), Means	M	L	13	—.02	—.07	—.00	...
		Russians, Means	M	L	15	—.03	—.12	—.01	...
		Russians, Means	F	L	15	.11	.31	.04	...
Stature	Biacromial dia./ Stature	Scots	M	L	25	—.41	—1.97	—.08	...
Stature	Chest cir.	Jews, Means	M	L	6	.38	.35	.40	89
		Turks, Osmanli, Means	M	L	20	.96	1.23	.74	165
		Arabs in Dobrouja	M	L	12	.60	.30	1.19	26
		English recruits	M	L	68	.28	.06	1.42	4
Stature	Chest cir./Stature	Kymris, Means	M	L	10	—.90	—57.84	—.01	...
		Celts, Means	M	L	9	—.93	—49.88	—.02	...
		French, Means	M	L	12	—.98	—54.05	—.02	...
		Peruvians, Means	MF	L	7	—.58	—13.05	—.02	...

		Peruvians, Means	MF	L	7	—.58	—13.05	—.02	...
Stature	Cephalic module	Pueblo Indians, Means	M	L	11	—.00	—.01	—.00	...
		Asiatic Russians, Means	M	L	13	—.72	—1.08	—.47	228
Stature	Cephalic module/ Stature	Indians, Means	MF	L	11	—.84	—220.33	—.00	...
Stature	Cephalic circ., horizontal	Macedonians, Means	M	L	6	.73	.24	2.23	11
Stature	Cephalic breadth	English (Flamborough)	M	L	73	.16	.15	.18	83
		English (Flamborough)	F	L	17	.44	.52	.36	145
		Scandinavians, Means	M	L	9	—.03	—.01	—.05	32
		Swedes, Means	M	L	25	—.70	—.48	—1.03	47
		Macedonians, Means	M	L	6	.42	.08	2.17	4
		Rumanians, Means	M	L	6	.95	4.87	.19	260
		Rumanians, Means	M	L	6	.92	5.82	.15	396
		Rumanians, Means	M	L	6	.94	3.74	.23	337
		Southeast Europeans, Means	M	L	21	.49	1.04	.23	446
		N.W. Coast of N. America, Means	M	L	7	—.42	—.38	—.47	82
		N.W. Coast of N. America, Means	F	L	7	—.44	—.32	—.62	51
Stature	Face breadth	Swedes, Means	M	L	25	—.42	—.33	—.54	60
		Macedonians, Means	M	L	6	.08	.02	.44	4
Stature	Cephalic height	Rumanians	M	L	13	.07	.06	.11	51
Stature	Cephalic length	Borneo	M	L	21	.09	.06	.14	44
		Southeast Europeans, Means	M	L	21	.50	1.39	.18	761
Stature	Face height	Macedonians, Means	M	L	6	—.20	—.04	—1.04	4

TABLE 2 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Stature	Femur length	Giants, Stature 2023–2364	M	L	12	.91	.60	1.38	44
		French	M	L	15	.99	1.07	.93	115
		French	F	L	17	.99	1.01	.98	103
		French criminals	M	L	20	.98	1.01	.95	106
Stature	Fibula	French	M	L	15	.99	1.00	.97	103
		French	M	L	17	.99	.91	1.10	82
Stature	Foot breadth	Indians (S.W. U.S. and N. Mexico), Means	M	L	15	.46	.30	.69	44
		Indians (S.W. U.S. and N. Mexico), Means	F	L	14	.49	.38	.62	61
Stature	Foot length	Susians (Persia), Means	M	L	11	.76	.82	.69	119
		Andamanese	M	L	48	.76	.54	1.08	49
		Andamanese	F	L	41	.53	.33	.84	39
		Indians (S.W. U.S. and N. Mexico), Means	M	L	15	.88	.87	.88	99
		Indians (S.W. U.S. and N. Mexico), Means	F	L	14	.81	.70	.94	74
Stature	Hand length	Susians (Persia), Means	M	L	11	.63	.43	.93	46
Stature	Head cir.	English, Means	M	L	5	.98	5.83	.17	3510
		Northern Beja (Ababda)	M	L	62	.05	.07	.04	189

		(Ababda)							
Stature	Head cir.	Northern Beja, Bisharin (Hamedarab)	M	L	30	.04	.05	.03	155
		Northern Beja, Bisharin (Arabs)	M	L	44	.44	.50	.38	132
		Andamanese	M	L	48	.25	.18	.34	55
		Andamanese	F	L	41	.01	.01	.02	65
Stature	Head length	Wales	M	L	64	.18	.22	.14	152
		Wales	M	L	116	.50	.62	.40	154
		Wales	F	L	32	—.09	—.12	—.07	179
		Wales (North Dyfi Basin)	F	L	34	.33	.39	.28	140
		Cyprus	M	L	29	.22	.30	.17	176
		Cyprus	M	L	70	.51	.56	.46	120
		Cyprus	M	L	54	.02	.02	.02	133
		Cyprus	M	L	53	.22	.18	.27	65
		Cyprus	M	L	65	.37	.34	.41	82
		Cyprus	M	L	118	.29	.24	.35	69
		Cyprus	M	L	14	.53	.37	.76	49
		Bavenda	M	L	168	.27	.30	.24	125
		Bavenda	F	L	56	.31	.41	.24	166
		Pauri Bhuiyas	M	L	100	.19	.17	.20	83
		New Guinea	M	L	20	—.01	—.01	—.01	59
		Enkomi	M	L	60	.19	.19	.19	101
		Leukoniko	M	L	88	.16	.14	.17	80
		Akonthon	M	L	27	.08	.07	.09	72
		Hagvis Ambrosios	M	L	12	.04	.02	.07	28
		Tanna (New Hebrides)	M	L	188	.24	.25	.24	108
		Kordofan	M	L	57	.47	.58	.38	151

TABLE 2 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Stature	Head length	English (Flamborough)	M	L	73	.28	.28	.28	102
		English (Flamborough)	F	L	17	.42	.61	.29	214
		Egyptians and Nubians, Means	M	L	20	.80	1.38	.47	295
		Albanians, Means	MF	L	11	.40	1.08	.14	740
		Philippines (Pagan), Means	M	L	7	—.14	—.15	—.13	113
		Philippines (Christian), Means	M	L	48	.42	.51	.34	147
		Scandinavians, Means	M	L	9	.07	.08	.06	138
		Barley, Herts., England, Means	M	L	15	.50	.61	.40	151
		Lolos (Chinese), Means	M	L	19	.17	.19	.15	128
		Swedes, Means	M	L	25	.70	.76	.64	120
		Macedonians, Means	M	L	6	.13	.03	.53	6
		Jews, Means	M	L	6	—.16	—.30	—.08	364
		Rumanians, Means	M	L	6	.94	3.74	.23	1574
		Rumanians, Means	M	L	6	.99	3.74	.26	1435
		Rumanians, Means	M	L	6	.96	3.80	.24	1563
		Eromanga (New Hebrides)	M	L	48	.20	.20	.20	98

Stature	Head length/Stature	Russians (before the famine), Means	F	L	17	—.72	—42.99	—.01	...
		Russians (before the famine), Means	M	L	18	—.67	—37.56	—.01	...
		Russians (after the famine), Means	F	L	17	—.57	—35.50	—.01	...
		Russians (after the famine), Means	M	L	18	—.70	—41.07	—.01	...
Stature	Humerus length	Giants, Stature 2023–2364	M	L	12	.83	.56	1.24	45
		Susians (Persia), Means	M	L	11	.81	.74	.90	82
		Andamanese	M	L	48	.66	.33	1.33	25
		Andamanese	F	L	41	.42	.22	.80	27
Stature	Intercristal breadth	Swedes, Means	M	L	17	.32	.28	.38	74
Stature	Leg length	Norwegians, Means	M	L	17	.91	.53	.16	334
		French criminals	M	L	20	.88	.94	.82	114
		New Guinea, Means	M	L	5	.98	.72	1.33	54
Stature	Leg length/Stature	Russians (before the famine), Means	F	L	17	—.08	—2.55	—.00	...
		Russians (before the famine), Means	M	L	18	—.12	—3.11	—.00	...
		Russians (after the famine), Means	F	L	17	.00	.23	.00	...
		Russians (after the famine), Means	M	L	18	—.07	—2.44	—.00	...
		Peruvians (Cuzco and Apurimas)	M	L	140	.34	13.68	.01	...
		Swedes, Means	M	L	25	.66	3.98	.11	...

TABLE 2 (*Continued*)

X	Y	GROUP	SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Stature	Length of left foot	Adult Egyptians and Nubians, Means	M	L	20	.73	.82	.66	125
Stature	Length of left middle finger	Adult Egyptians and Nubians, Means	M	L	20	.56	.50	.63	80
Stature	Length of right arm/Stature	Adult Melanesians, Means	M	L	5	.17	87.49	.01	...
Stature	Mouth breadth	Indians (S.W. U.S. and N. Mexico), Means	F	L	16	.67	.47	.95	49
		Indians (S.W. U.S. and N. Mexico), Means	M	L	19	.35	.39	.31	124
		American Indians and whites, Means	M	L	6	—.22	—.11	—.47	23
		American Indians and whites, Means	F	L	6	—.10	—.03	—.35	8
Stature	Nasal breadth	Macedonians, Means	M	L	6	—.43	—.05	—3.48	2
Stature	Nasal height	Macedonians, Means	M	L	6	.05	.01	.27	3
Stature	Presacral vertebral length/Stature	Japanese adults, Means	M	L	6	—.98	—83.69	—.01	...
		Japanese adults, Means	F	L	5	—.09	—3.93	—.00	...
Stature	Radius length	Giants, Stature 2023-2364	M	L	12	.90	.46	1.76	26
		Susians (Persia), Means	M	L	11	.89	.62	1.27	49

Stature	Shoulder breadth/ Stature	Peruvians (Cuzco and Apurimac)	M	L	140	—.26	—14.64	—.00	...
Stature	Sitting height	Mainly U.S. soldiers, Means	M	L	9	.92	.96	.88	109
		Groups of mankind (1500-1595), Means	F	L	34	.14	.08	.24	32
		Groups of mankind (1512-1598), Means	M	L	55	.63	.36	1.10	32
		Groups of mankind (1610-1698), Means	M	L	113	.50	.28	.90	31
		Groups of mankind (1700-1785), Means	M	L	35	.21	.07	.62	11
		Pueblo tribes, Means	M	L	17	.95	.84	1.07	78
		Pueblo tribes, Means	F	L	15	.91	1.04	.79	132
		Hausa	M	L	106	.74	.73	.76	97
		Ethnic groups, inc. Negroids, Caucasoids Mongoloids, Means	F	L	34	.77	.65	.91	71
		East Aberdeenshire, Means	M	L	23	.49	.34	.70	48
		East Aberdeenshire, Means	F	L	23	.69	.41	1.17	35
		Asiatic Negritos, Means	M	L	5	.00	.00	.02	1

TABLE 2 (*Continued*)

X	Y		SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Stature	Sitting height/Stature	Negrillos, Means	F	L	7	—.93	—4.88	—.18	...
		Negrillos, Means	M	L	12	—.87	—3.36	—.23	...
		Mainly U.S. soldiers, Means	M	L	9	—.30	—84.16	—.00	...
		Groups of mankind (1500-1595), Means	F	L	34	—.62	—9.74	—.04	...
		Groups of mankind (1512-1598), Means	M	L	55	.05	1.03	.00	...
		Groups of mankind (1600-1698), Means	M	L	113	—.04	—.77	—.00	...
		Groups of mankind (1700-1785), Means	M	L	35	—.17	—2.33	—.01	...
		Peruvians (Cuzco and Apurimac)	M	L	140	—.33	—13.48	—.01	...
		Ethnic groups, inc. Negroids, Caucasoids Mongoloids, Means	F	L	34	—.12	—4.65	—.00	...
		African Pigmies, Means	M	L	6	—.77	—25.35	—.02	...
Stature	Span	Soko	M	L	11	.91	.77	1.08	71
		Buduma	M	L	32	.76	.64	.91	70
		Pamirs, Means	M	L	14	.85	.73	.99	74
		Negritos	M	L	47	.83	.79	.86	92
Stature	Span	Bushongo	M	L	18	.91	.77	1.09	70

Stature	Span	Bushongo	M	L	18	.92	.77	1.09	70
		Korawp	M	L	13	.31	.09	.10	89
		Albanians, Means	M	L	6	.94	1.27	.71	179
		Congo	M	L	34	.82	.65	1.02	64
		Norwegian recruits, Means	M	L	19	.66	.61	.71	85
		Kotoko	M	L	20	.68	.27	1.68	16
		Kanuri	M	L	16	.83	.46	1.48	31
		Zambales	F	L	30	.91	.72	1.15	63
		Ekoi	M	L	23	.65	.53	.79	66
		Arabs	M	L	19	.81	.71	.93	76
		Chinese, Means	M	L	25	.73	.58	.92	63
		Africans, Means	M	L	13	.22	.09	.59	15
		Nicobarese	M	L	14	.54	.43	.67	65
		Nicobarese	M	L	39	.73	.68	.80	85
		Kubilu	M	L	10	.70	.78	.63	124
Stature	Span/Stature	Melanesians (New Guinea), Means	M	L	5	.45	38.03	.00	...
		Peruvians (Cuzco and Apurimas)	M	L	140	—.11	—2.90	—.00	...
Stature	Thoracic cir./Stature	Russians (before the famine), Means	M	L	18	.33	5.67	1.95	...
		Russians (after the famine), Means	M	L	18	.04	.93	.00	...
Stature	Tibia length	Giants, Stature 2023-2064	M	L	12	.96	.52	1.78	29
		Andamanese	M	L	48	.78	.51	1.20	42
		Andamanese	F	L	41	.57	.34	.95	36
		French	M	L	15	.99	1.09	.91	119
		French	F	L	17	.95	.83	1.08	78

TABLE 2 *(Continued)*

X	Y		SEX	MATERIAL	NO.	r_{xy}	$r_{xy}(\sigma x/\sigma y)$	$r_{xy}(\sigma y/\sigma x)$	RATIO
Stature	Trunk length	Swedes, Means	M	L	17	—.26	—.31	—.23	135
Stature	Trunk/Stature	Russians (before the famine), Means	M	L	18	—.70	—13.50	—.04	...
		Russians (after the famine), Means	M	L	18	—.55	—8.78	—.03	...
		Swedes, Means	M	L	25	—.65	—3.99	—.11	...
Stature	Weight	Caucasoids, Means	MF	L	16	.05	.04	.07	63
Height of sternal notch	Height of sternal notch/Stature	Europeans, Means	MF	L	8	.50	3.17	.08	...
Sternum to ischium	Sternum to ischium/ Stature	African Negroes, Means	M	L	13	.81	17.23	.04	...
Thoracic cir./Stature	Trunk/Stature	Russians (before the famine), Means	M	L	18	—.18	—.20	—.16	...
		Russians (after the famine), Means	M	L	18	.10	.06	.16	...
Height of trunk	Biacromial dia./ Height of trunk	Ethnic group, Means	M	L	10	—.87	—2.19	—.35	...
Height of trunk	Height of trunk/ Stature	Ethnic group, Means	M	L	10	.73	10.05	.05	...
		Peruvians, Means	MF	L	7	.71	8.52	.06	...

ON THE INTERDEPENDENCE OF THE LENGTH OF LIFE OF HUSBAND AND WIFE

BY ANTONIO CIOCCO[1]

INTRODUCTION

THE existence of some association between the duration of life of husband and wife was apparently first pointed out by Pearson and associates ([Anon.] 1903) almost 40 years ago. Since that pioneer investigation others have examined the question following the same analytical technique. The results of all these studies are summarized in Table 1.

TABLE 1

Correlation between age of death of husband and wife as reported by several authors

AUTHORS		CORRELATION COEFFICIENT = r
Pearson, *et al.*	Yorkshire (tombstones).....	.2200 ± .0244
	Oxfordshire (tombstones).....	.2500 ± .0211
	London (tombstones).....	.4204 ± .0176
	Soc. of Friends (genealogies).....	.1999 ± .0212
Pearl and Pearl	Long. Ser. F × M* (genealogies)....	.068 ± .035
	Long. Ser. FF × FM (genealogies)	.239 ± .033
	Long. Ser. MF × MM (genealogies)	.069 ± .035
	F.H.R. Ser. F × M (genealogies)....	.403 ± .047
	F.H.R. Ser. FF × FM (genealogies)	.126 ± .056
	F.H.R. Ser. MF × MM (genealogies)	.100 ± .056
Ciocco	Wash. Co. death certificates.....	.5594 ± .0092

* F = father, M = mother, FF = father's father, etc.

[1] From the Division of Public Health Methods, National Institute of Health, U.S. Public Health Service. This is the seventh of a series of papers entitled: Studies on the Biological Factors in Public Health.

From Table 1 it is seen that a substantial correlation coefficient was found in the case of the London tombstone series of Pearson *et al.*, the parents of the F.H.R. series of Pearl and Pearl (1934), and the Washington County mortality data examined by Ciocco (1940). Low positive, but significant with respect to the probable error, appear the coefficients for the Oxfordshire and Yorkshire tombstone data, and the records of the Society of Friends of Pearson's study, and for the paternal grandparents of Pearl and Pearl's Long. series. Correlation coefficients of zero order result for the parents, and the maternal grandparents of Pearl and Pearl's Long. series, and for the maternal and paternal grandparents of the F.H.R. series. So it appears that the association is not revealed by all the samples. Furthermore, the high value for the London tombstone series being so out of line with the values for their remaining samples led Pearson and his associates to discount it. They believed it to be spurious since in urban areas the probability that both the husband and wife will be buried in the same cemetery may depend upon the interval between the death of the spouses. In the investigation cited, one of the collaborators, F. E. Lutz, attempted to arrive at a measure of the correlation expected in a random assortment of dead men and women. Therefore, he ordered the tombstone records in a series, and formed couples by taking with the record of each man that of the wife of a man ten places removed in the series from the first. The resulting correlation coefficient was found equal to .0086 $\pm$ .0228, that is practically zero. Thus these investigators were satisfied to have demonstrated that the duration of life of husband and wife was not independent and following additional analysis, which will be discussed later, concluded that the association is a consequence of homogamic mating. On the other hand, Pearl and Pearl, in view of the range exhibited by the coefficients they obtained, did not seem convinced that any association is present or, at least, that assortative mating relative to length of life was demonstrated by their material. These authors, in addition, pointed out that by calculating the product-moment correlation between the age of death of the paternal grandfather and of the maternal grandmother, and between the age of death of the maternal grandfather and of the paternal grandmother in the two series they examined, the coefficients ranged from .039 $\pm$ .056 to .127 $\pm$ .035. So it would seem that the presumption of the existence of an association between the duration of life of spouses cannot be considered definitely established. However, it is indirectly strengthened by the observations

of Lotka (1931) on the frequency of "absolute" orphans, that is of orphans who have lost both of their parents. Lotka found that the chances of becoming an absolute orphan at a given age was greater than the product of the chances of losing one or the other parent at that age. From this finding it could be inferred, as Lotka himself noted, that the death of husband and wife are not independent events. The presumption being so advanced, it seems pertinent because of the broad general public health significance of the phenomenon to investigate it further and with a different analytical technique. This paper reports on such an investigation which has had for its purpose to determine specifically whether the differences between the age of death of husband and wife as observed in this sample still persist when the age of marriage, the differences between age of marriage, and age at time of becoming widowed, are taken into account in relation to the life expectancy of the men and women of this group. Furthermore, the differences between the age of death of husband and wife will be examined with reference to duration of marriage and by this means it is hoped to elucidate somewhat the significance of the phenomenon.

MATERIAL

The material for this study derives from the records on the mortality of husbands and wives already discussed in earlier papers (Ciocco, 1940-1941a). Of the 2571 married couples for whom death certificates have been located in the files of the Washington County Health Department, the age and date of marriage was definitely known, also from official sources in the case of 1222 couples married only once, and the data on these couples constitute the basis for the analysis discussed in the present paper.

The latter died between 1898 and 1938 and the mean age of death of the husbands is 69.3 ± .33 years, that of the wives is 69.0 ± .41. In the case of the 2571 couples, the sample from which this is drawn, the mean age of death of the males is 68.8 ± .26 and for the females it is 68.1 ± .29. Relative to age the subsample of 1222 couples, therefore, agrees well with the parental population from which it originates.

In both instances one finds that the males lived slightly longer than the females. This finding which may at first seem contrary to expectations has been observed for other samples of husbands and wives.

For example, it appears in the four groups studied by Pearson and associates, in the maternal grandparents and in the parents of the F.H.R. series of Pearl and Pearl, and was observed in another sample of spouses studied by Ciocco (1941b). According to Pearson, *et al.*, the reason for this discrepancy from the general fact that at practically all ages the mortality rate of the male is higher than that of the female is that the sex differential mortality is primarily a consequence of the high mortality of single men. The official statistics for those countries that publish mortality data according to marital status demonstrate, in fact, that the mortality of married men is practically the same as that of married women, in some cases slightly higher, in some cases slightly lower; but there is always a distinctly higher mortality of single men when compared to single women. There is also another aspect of the question to consider if an explanation is desired as to why in samples of husbands and wives such as the one under discussion the males exhibit an equal or maybe slightly longer duration of life when compared to the females. Although there is a high correlation between the age of marriage of husband and wife, on the average the men are older than their wives by amounts which vary from 3 to 5 years as the data on this community have shown. This means that husbands and wives in reality belong to different generations and, except under stationary conditions at the same chronological age, will be subject to different chances of death in addition to whatever sex differential relative to mortality there may exist.

The duration of the marriage, i.e., the interval between the day of marriage and the death of the first spouse to succumb varies in the 1222 couples from less than 1 year to 66 years. The mean duration of marriage equals 37.26 $\pm$ .39 years. There are no official statistics with which to compare this average but it is of interest to point out that Lotka's estimates of the probability of becoming an orphan at a given age reveal a parallelism to the above figure which while not entirely unexpected is noteworthy. Lotka calculated on the basis of the 1920 white population of this country that 50 percent of persons are orphaned of the father by the time they reach approximately 37 years of age, and of the mother at about 42 years. The agreement which may be inferred to exist between Lotka's results and the observations on the group studied here is probably the consequence of the relationship between duration of marriage and age of offspring, a relationship which could probably be determined with some precision if more information were available relative to duration of marriage.

The other characteristics of the sample of 1222 couples that constitute the material for this investigation are those already described in the reports cited and the reader can refer to them. The question of a possible statistical artefact due to the procedure used in collecting the material will also be discussed in a subsequent section. It may be pointed out here that the only criterion employed in selecting the 1222 couples from the total group of 2571 was the existence of an official record in Washington County on the date and age of marriage. It must be assumed then that all these persons lived the greater part of their lives in this county.

OBSERVED AND THEORETICAL DIFFERENCES BETWEEN THE AGE OF DEATH OF HUSBAND AND WIFE

The first step in the present analysis is to determine whether the observed differences between the length of life of husband and wife is equal to or less than those expected if the conjugal partners from the time of their marriage experienced the same risk of mortality as the men and women of the group or general population. The calculation of the theoretical differences for the comparison involves therefore (a) age at marriage, or beginning of the risk of mortality, and (b) the age and sex characteristics of mortality after that age. The age of marriage of the couples of this sample is known, as has been said. The age and sex characteristics of mortality after marriage may be obtained by constructing in the usual manner life tables for the cohorts of men and women, respectively. The starting point for the life table is the lowest marriage age of each cohort. With these data at hand, the determination of the expected differences follows the elementary probability theorem on the concurrence of two independent events.

Let ${}_r|q_x = \frac{dx}{l_r}$ be the probability that a man married at age r will die at age x.

So,
$$\sum_{x=r}^{x=\omega} {}_r|q_x = 1.$$

Similarly, let us call ${}_s|q'_x$ the probability that a woman married at age s will die at age x.

Then ${}_r|q_x \times {}_s|q'_x$ will be the probability that both the man and woman will die at age x.

It follows, that for couples for whom the age at marriage of the man was r and that of the wife was s, the summation:

$$r|q_x \; s|q'_x + r|q_{x+1} \; s|q'_{x+1} + \cdots\cdots + r|q_\omega \; s|q'_\omega = {}_{rs}|Q_0$$

measures the probability that the husbands and wives will die at the same age.

Similarly,

$$r|q_x \; s|q'_{x+1} + r|q_x \; s|q'_{x-1} + \cdots\cdots + r|q_{\omega-1} \; s|q'_\omega = {}_{rs}|Q_1$$

measures the probability that husbands and wives will die one year apart in age.

Therefore, from

$$\sum_{k=0}^{k=n} k \; {}_{rs}|Q_k \text{ and } \sum_{k=0}^{k=n} k^2 \; {}_{rs}|Q_k$$

the mean and standard deviations of the distribution of the probable differences between the age of death of husbands and wives who married at age r and s, respectively, will be obtained. Combining the summations for all the marriage age pairings present in this sample one arrives at the theoretical differences for the whole group.

The mean theoretical difference thus determined, according to the postulates which will be termed hypothesis I, is compared in Table 2 with the average of differences between the age of death of husband and wife as observed in the sample. It will be noted that the theoretical differences have also been calculated on the basis of the Life Tables for the white population of Continental United States, 1929-1931, and of the Original Registration States, 1900-1902. It has appeared worthwhile to include the computations based on the last two mentioned Life Tables for two reasons. The first is that it will be possible to comprehend more clearly what effects, if any, result from the peculiarities of mortality data based on married and widowed persons alone. The second and most important is that the opportunity is thus offered to verify the direction of the changes relative to the theoretical differences between the length of life of husband and wife when the mortality characteristics are altered as they have been from 1900-1902 to 1929-1931.

The data of Table 2 indicate:

1. The observed mean of the differences between the age of death of husband and wife is 9.93 years and is almost 4 years less than the calculated according to the mortality characteristics of this sample

TABLE 2

Observed and theoretical (hypothesis I) differences between the age of death of husband and wife. 1222 white couples both of whom died between 1898 and 1938 in Washington County (Maryland)

	YEARS DIFFERENCE IN AGE OF DEATH			
	Sum	σ of sum	Mean	σ of mean
Observed	12130	294.4	$9.93 \pm .24$	$8.42 \pm .17$
Theoretical according to mortality of:				
1. This sample	16949	385.7	$13.87 \pm .35$	$12.16 \pm .25$
2. U.S. Life Tables, 1929-31	20395	458.4	$16.69 \pm .49$	$17.19 \pm .35$
3. U.S. Life Tables, 1900-02	22847	495.8	$18.90 \pm .58$	$20.11 \pm .42$

(assuming that the deaths of husbands and wives are independent events); and over 6 years and 9 years less, respectively, than that calculated according to the U. S. Life Tables of 1929-1931 and of 1900-1902.

2. The observed difference between the age of death of husband and wife is significantly less than that calculated according to any of the Life Tables employed. The deviation between the observed mean and the theoretical mean is over 10 times its standard error in all instances. In the case of the observed series the standard deviation has been computed in the usual manner from the distribution of the differences, but for the theoretical series, as the formula indicates, the standard deviation is calculated from the sum of the variances about the theoretical difference probable for each husband-wife marriage age combination. Thus, it is more appropriate to evaluate the divergence between observed and theoretical differences in terms of the sigma of the latter. It is found that the observed mean of differences deviates 11 to 15 standard errors removed from the theoretical means.

It is of interest to point out that the dispersion of the distribution of calculated differences is least for the theoretical series based on the mortality of the present sample. This is to be expected since the Life Table data for the population of the United States cannot, of course, express exactly the mortality of the county and of the sample with which we are concerned. The group examined in this paper does

not include the deaths of single persons, and has achieved a more advanced age than that of the Life Table populations employed. The age differential has as a consequence the reduction of the dispersion of the distribution of differences. The comparison of the calculated series based on the 1900-1902 Life Table with that based on the 1929-1931 Life Table illustrates the effects of a decrease in the probability of death in the younger ages and a corresponding increase in the older ages. Thus, the standard deviation of the mean of the differences equals 20.11 years when the 1900-1902 Life Table is employed and falls to 17.19 years when the 1929-1931 Life Table is used. In view of these considerations and findings it seems permissible to infer that for purposes of devising theoretical series of differences with which to compare the observed, it is sufficient to rely on the mortality characteristics of the sample being investigated.

The main point of the comparison between the observed differences and the theoretical calculated according to hypothesis I is that it is rather strikingly revealed that with reference to length of life husbands and wives differ from each other less than do the men and women paired at random, but who started life together at the same age as did the conjugal partners and were subject to the same mortality experience thereafter. It could therefore be concluded, as others have, that there exists association between husbands and wives relative to duration of life.

To test further the validity of this conclusion and also to clarify the modalities of the apparent association another set of conditions which will constitute hypothesis II can be postulated for the calculation of a series of theoretical differences between the age of death of husband and wife. This hypothesis will seek to evaluate the difference expected between the age of death of husband and wife on the basis of the mortality characteristics of a group of persons who survive their spouses at a given age. While hypothesis I assumes that the deaths of spouses subsequent to marriage are independent events, hypothesis II assumes that only the mortality of the surviving spouse is independent. It is obvious that one of the factors which plays an important role in determining the difference between the duration of life of husband and wife is the achieved age at the death of the spouse who succumbs first. If this spouse dies at an advanced age—recalling the high correlation between the marriage age of spouses—the biological limitation imposed upon the longevity of man will by itself reduce the probability of large differences

between the age of death of the marital partners. Since the present sample of men and women is characterized by a high average duration of life it is pertinent to evaluate how much the apparent association between spouses could not be the result of the mentioned conditions, and therefore a theoretical series of differences has been calculated according to the following scheme.

Let x be the age of death of the spouse who succumbed first and y the age of the survivor at that time. Then $q_v = \frac{dv}{ly}$, $v > y$, will be the probability of death at age v of the survivor aged y. So,

$$\sum_{k=y}^{k=\omega} q_k = 1$$

If $a_y = x - y$ and $a_v = x - v$ then the summation

$$\sum_{k=y}^{k=\omega} |a_k| q_k$$

will give the probable number of years that will separate the age of death of one spouse from that of the other.

By this procedure, the age of death of one partner being fixed, one arrives at a measure of the difference between the age of death of spouses (whose marriage age diverged by a stated number of years) assuming that the mortality of the surviving spouse subsequently follows the age and sex characteristics of the group to which he or she belongs. In the calculation of the theoretical series according to hypothesis II only the mortality data based on the present sample have been employed since the preceding comparison of the results obtained from using the data of the 1900-1902 and 1929-1931 U. S. Life Tables show that the picture of the deviation of observed from theoretical is the same. The distribution of the theoretical differences according to hypothesis II and the devation of the observed differences from the theoretical are summarized in Table 3.

From Table 3 the first point to note is that the mean of the theoretical differences calculated according to hypothesis II is practically identical to that calculated on the basis of hypothesis I and both are significantly larger by about 4 years [2] than the mean of the observed

[2] Due to the skewness (*vide infra*) of the two distributions compared the mean deviation between theoretical and observed differences is determined from the calculation of the deviation present for each of the 1222 couples.

TABLE 3

Observed and theoretical (hypothesis II) differences between the age of death of husband and wife

CLASS OF THEORETICAL DIFFERENCES (*in years*)	NUMBER OF COUPLES	MEAN DIFFERENCES (*in years*)		
		Theoretical	Observed	Theoretical — Observed
Less than 5	139	3.95	3.53	.42
5–9	378	7.37	6.04	1.33
10–14	304	12.39	10.16	2.23
15–19	157	17.28	12.87	4.41
20–24	100	22.33	14.73	7.60
25–29	54	27.60	17.87	9.73
30–34	42	32.19	16.67	15.52
35–39	27	37.49	20.96	16.53
40–44	11	43.33	27.18	16.15
45 and over	10	48.20	24.30	23.90
All couples	1222	13.80	9.93	3.87 ± .22

differences between the age of death of husband and wife. Therefore, it seems justifiable to conclude that there exists interdependence between spouses relative to duration of life since a difference between the age of death of spouses as low as that observed here could not be obtained from the random coupling of men and women when these random couples have in common with the spouses the following attributes: (1) age of marriage, (2) age difference at marriage, (3) life expectancy after marriage, (4) age at beginning of widowhood, (5) life expectancy after widowhood.

Summing up, the analysis so far performed may also be regarded as an attempt to arrive at a formulation of conditions from which a distribution of differences identical with the observed will be obtained. It is in essence a problem of rational curve-fitting. The data of Tables 2 and 3 indicate that the two series of conditions postulated are inadequate to describe the phenomenon observed and the graphic representations of the observed and theoretical distributions illustrate the point clearly.

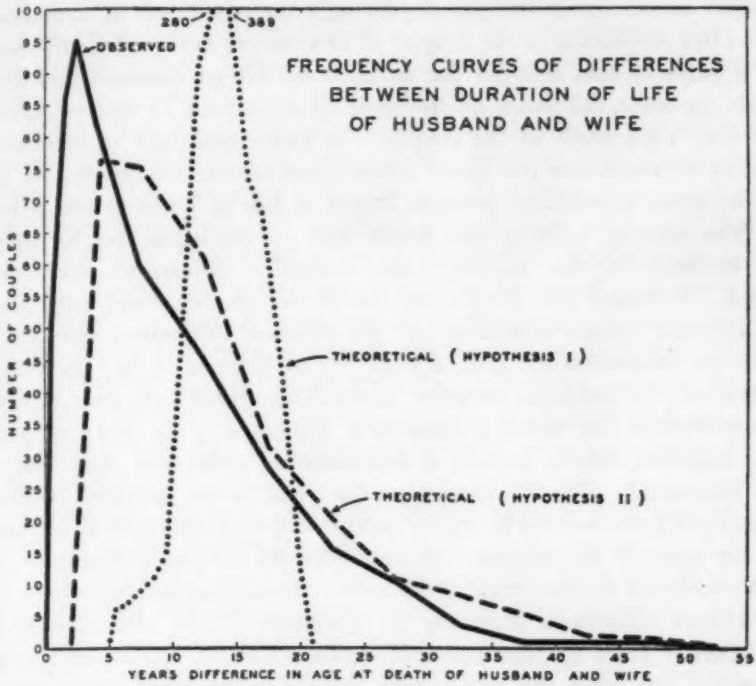

FIG. 1. OBSERVED AND THEORETICAL FREQUENCY DISTRIBUTIONS OF THE DIFFERENCES BETWEEN THE AGE OF DEATH OF HUSBAND AND OF WIFE

It is seen from Fig. 1 that the distribution of the differences resulting from hypothesis I (based on the mortality of this sample) is more or less symmetrical, is limited in range on both sides and hardly resembles the observed distribution. More than half of the couples are expected to exhibit differences in age of death of 13-14 years. This concentration of the cases in two classes reflects the narrow range of ages within which the majority of marriages takes place.

The conditions which underlie hypothesis I are obviously not sufficient to reproduce the observed differences between the age of death of husband and wife. On the other hand, the frequency curve obtained according to hypothesis II has the general configuration of the observed. Both are markedly skew towards the large differences and the upper limit is identical in both. However, the curve of the theoretical differences is constricted at its lower end. Differences as small as those

actually noted cannot be achieved through the conditions of hypothesis II. Over 18 percent of the couples of this sample exhibited a difference of 2 years or less between the duration of life of husband and wife while the same difference on the basis of hypothesis II was calculated for only 1.3 percent of the couples. It seems then safe to infer that besides the conditions postulated above, other factors are responsible for the apparent associations between length of life of husband and wife.

The data of Table 3 also throw light on the modalities by which the deviation of the observed from theoretical differences have come about. It is seen that for the couples for whom theoretical differences of less than 5 years were expected, the observed differences were lower than the theoretical by .4 of a year. With increase in the theoretical differences the deviation between observed and theoretical rises rapidly. Those couples for whom a theoretical difference of 45 years or more was expected exhibit actually a difference 24 years less than that of the theoretical. The significance of the trend in the deviation between theoretical and observed is readily understood, when attention is focussed on the ages of the persons that constitute the couples included in the several classes of theoretical differences. Those couples for whom the theoretical differences according to hypothesis II are calculated to be less than 5 years are obviously the spouses *both* of whom were at an advanced age when the first spouse died. On the other hand, among the couples for whom the age difference at death was expected to be 45 years or over are included the spouses *both* of whom were young at the time of the death of the first of the spouses. In the process of estimating the life expectancy of the surviving spouse we have assumed that he or she was subject to the mortality characteristics of the group. When it is noted, however, that the deviation of the observed from the theoretical is very small for the couples both of whom have reached an advanced age at the death of one of the spouses, and, that the deviation increases markedly as one proceeds towards spouses both of whom were young at the time of death of the first spouse to succumb, it would seem that the assumption that the general mortality characteristics of the group holds for all the spouses is not wholly tenable. Apparently the life expectancy of the young widowed has been overestimated in these calculations. In order to have the theoretical series approximate more closely the observed it would seem necessary to modify accordingly the estimate of the survival of the young widowed of relatively short-lived persons. The need for such a correction must be taken as a manifesta-

tion of the association between spouses relative to longevity. That is to say, being married the couples of this sample segregate into men and women both of whom demonstrate to a similar degree divergence from the longevity of their respective sex.

What brings about this segregation? Two main groups of factors or the combination of both are probably involved. The first is constituted by those elements that husbands and wives have in common and share throughout their conjugal life: hygiene, diet, and specific mode of living. The second group of factors includes the elements that enter into marital selection: race, constitution, social and economic status. From the data at hand it is not possible to distinguish precisely between the two groups of factors or the elements included in each group. However, as will be done in the next section, an indirect measure may be obtained of the influence of the first group by examining the duration of marriage together with the differences between the age of death of husband and wife.

Before proceeding to this stage of the analysis it is well to take advantage of the opportunity offered by the theoretical series of hypothesis II to consider more in detail the possibility that a statistical artefact connected with the sampling may bring about the above results. This possibility must always be kept in mind because by the process of collecting the material there have been excluded those spouses for whom there is a record that one died between 1898 and 1938 but no record is available regarding the survivor. Without an extensive survey not feasible at the moment it is not possible to estimate what proportion of these so-called survivors are dead and what proportion are actually still alive. If this proportion is high one could presume that if the present study had covered a 60 or 70 year span instead of 41 years as it does, the observed difference between the length of life of husband and wife would have been larger, and maybe the above noted deviation between theoretical and observed differences would have been rendered insignificant. However, preliminary analysis of the original 2571 couples from which this sample is drawn indicated that the correlation coefficients of the age at death of the spouses calculated for subdivisions of the 41-year period studied were not essentially different one from the other. Nevertheless, in order to determine if the technique employed here leads to a corresponding result, the 1222 couples of the present sample will be arranged into two groups defined as follows:

A. Both spouses died between 1898 and 1918 inclusive; or one spouse died between 1898 and 1918 inclusive, and the other between 1919 and 1938 inclusive.

B. Both spouses died between 1919 and 1938 inclusive.

Thus group A and group B, respectively, contains the data on spouses both of whom died within a span of 21 and 20 years; but in addition group A contains couples who would not have been selected if the collection of the material had not extended for 20 more years. If it is realized, as Spiegelman (1936) has shown, that in this country a woman aged 50 and 10 years younger than her husband will live an average of 15 years after his death, provided she survives him, while a man also aged 50 and 5 years younger than his wife will live an average of 13 years, if he survives her, then it is clear that by extending the period of the investigation by 20 additional years a high proportion of the survivors will have been covered. There are 694 couples included in group A, and for them the observed difference between the age of death of the spouses is 3.35 ± .33 years less than the theoretical calculated according to hypothesis II. Group B includes 528 couples and the observed difference is 4.45 ± .28 years less than the mean of theoretical differences. In each case the deviation between observed and theoretical is statistically significant. Therefore, it appears that the addition of 20 more years of observations has reduced by about one year the deviation between theoretical and observed, but the pattern of the phenomenon, the association between husbands and wives relative to duration of life, is not substantially altered. In view of this finding and considering that the whole sample studied involves 41 and not 21 years of observation, the conclusion would seem warranted that the apparent interdependence between spouses with respect to age of death is real.

DURATION OF MARRIAGE AND DIFFERENCES BETWEEN AGE OF DEATH OF HUSBAND AND WIVES

If the resemblance between husbands and wives with reference to longevity is an outcome of the immediate environment particular to the conjugal pair it would seem *a priori* that the duration of the marital union (the time from marriage to the death of one of the spouses) would affect the difference in the ages of death of the pair. Specifically, under these conditions, the longer the duration of marriage the closer

would be the resemblance of the spouses relative to duration of life. The data on this relationship as observed in this sample are summarily described in Table 4.

From Table 4 it will be first of all noted that with increase in the duration of marriage the differences between the age of death of husband and wife decreases. For marriages which lasted less than 20 years, the mean of the differences between the ages of the spouses is 16 years; the mean falls to 7 years for the couples who have been married 40 years or more. Before accepting the above results as indicative of the influence of the marital union on the resemblance between spouses relative to longevity let us consider those elements that can affect both of the variables under discussion. It is obvious that in order to achieve a long marriage *both* of the spouses must have married young and lived to an advanced age. A short marriage, on the other hand, may be the result of any of the following conditions: (a) *both* spouses married young and were short lived, (b) *both* spouses married at an advanced age, (c) *both* spouses were young at marriage and one was short-lived, (d) one of the spouses was already high in years at marriage. Therefore, the principal immediate elements that can influence both the duration of marriage as well as the difference in age of death are: (1) age of marriage, (2) difference between age of marriage of husbands and wives, (3) age of death of the spouses.

Let us now examine the significance of these elements in terms of the problems here studied. First, it will be asked whether the relation between the duration of marriage and the differences between the age of

TABLE 4

Duration of marriage and observed and theoretical (hypothesis I, II) differences between age of death of husband and wife

DURATION OF MARRIAGE (*in years*)	NUMBER OF COUPLES	DIFFERENCES IN AGE OF DEATH (*in years*)		
		Observed	Theoretical Hypothesis I	Theoretical Hypothesis II
Less than 20	155	15.86	13.11	27.32
20–39	492	11.55	13.79	15.77
40 and over	575	6.93	14.14	8.47

death of husband and wife could be expected on the basis of the age of marriage and subsequent mortality of random pairings of the men and women of this sample. In other words, the same question will be asked as in the previous section, and for each duration of marriage class the theoretical differences between the age of death of husband and wife will be calculated according to hypothesis I.

It is apparent from Table 4 that the theoretical series calculated according to hypothesis I exhibits an almost uniform trend with increase in duration of marriage. The theoretical difference equals 13 years for the group whose marriage lasted less than 20 years and is 14 years for the couples who remained together for 40 years or more. The comparison of the observed differences with the theoretical calculated according to hypothesis I leads to two inferences. The first is that the marital partners who were destined to live a long married life revealed at the time of marriage almost the same life expectancy as did the couples whose marriage was interrupted early by the death of one of the spouses. The second is that the slight upward trend in the theoretical difference between the age of the spouses as duration of marriage rises must be attributed to the fact that the couples whose marriage lasted a long time were on the average younger than the others at the time of marriage. In conclusion, it would seem that the observed duration of marriage trend of the differences between the age of death of husband and wife could not be expected on the basis of random couplings of men and women who married at the same age and were subjected after marriage to the same mortality of the men and women of this sample. However, the assumptions which underlie hypothesis I do not involve the achieved age at the beginning of widowhood and subsequent survivorship and so, a theoretical series according to hypothesis II has been calculated.

When the hypothesis II series is compared to the observed differences the following points are worthy of note:

1. The theoretical series of differences exhibits the same trends as the observed. From a mean of 27 years for the couples whose marriage lasted less than 20 years the difference falls to 8 years for the couples married for 40 or more years preceding the death of one of the spouses. It would thus seem that the observed decrease of the differences between the age of death of husband and wife in relation to increase in the duration of marriage could be explained simply as a consequence of

the age of the widowed and the chances of death associated with age from the beginning of widowhood.

2. At all points this theoretical series reveals a greater difference than the observed. So, one sees again that the observed differences because of their relative smallness indicate that between husbands and wives there is resemblance with respect to duration of marriage.

3. The divergence between theoretical and observed is greatest for those couples who have experienced the shortest marital union and least for the couples that have experienced the longest marital union.

Consideration of the last finding together with that described under (1) raises a strong doubt as to the real significance of the trend of the observed differences according to duration of marriage. Recalling from the preceding section that the observed differences increase also with increase in the theoretical differences calculated according to hypothesis II it becomes pertinent to examine more in detail the relationship between theoretical and observed differences with reference to duration of marriage. Table 5 summarizes the data regarding these variables and from it the first point to note is the distribution of the couples. The

TABLE 5

Observed differences between age of death of husband and wife in relation to duration of marriage and theoretical (hypothesis II) differences

CLASS OF THEORETICAL DIFFERENCES (*in years*)	DURATION OF MARRIAGE (*in years*)					
	Less than 20		20–39		40 and over	
	Number of couples	Observed differences (*in years*)	Number of couples	Observed differences (*in years*)	Number of couples	Observed differences (*in years*)
Less than 5	3	9.00	20	4.00	116	3.31
5–9	18	6.28	80	6.65	280	5.81
10–14	14	15.36	146	9.82	144	9.99
15–19	11	12.00	116	12.59	30	14.27
20–24	12	11.58	83	14.78	5	21.40
25 and over	97	18.78	47	20.23	...	....

couples with long duration of marriage are concentrated in the classes of small theoretical differences while the couples for whom the theoretical differences (because of the age of death of one spouse and of the age of the widowed at the time) are large are those whose marriage lasted a relatively short time. This finding, while not entirely unexpected, reveals rather clearly that the bulk of the deviation between theoretical and observed is furnished by the couples who were married for a relatively short time. Furthermore, it becomes obvious, that the age achieved by the partners at the time of the death of the first spouse must be given due weight when the effects of duration of marriage on the differences between the length of life of spouses is studied, and one should examine the trend of the observed differences within groups that are relatively homogeneous with respect to the chances of achieving a stated difference. Therefore, if duration of marriage is a prime factor involved it should be expected that within each theoretical difference class the observed differences will decrease with lengthening of duration of marriage.

Inspection of Table 5 brings out that no such trend is consistently present. The difference for the 40 and over group is less than that for the preceding group when the theoretical classes "less than 5 years" and "5-9 years" are considered but it is greater in the case of the "10-14 years" and higher theoretical differences classes. Similarly, the observed differences in the 20-39 group are higher than those of the less than 20 group in 4 out of 6 instances.

As further support for the finding that within each theoretical difference class the observed differences do not consistently decrease it may be noted that the concomitant increase of the theoretical and observed differences is practically identical for all three duration-of-marriage groups. This can be shown by substituting for the actual observed differences in each duration of marriage group the corresponding values of the observed differences for all three groups combined. As a result, it is found that the total calculated difference becomes 16.6 years for the less than 20 years duration-of-marriage group; 11.38 years for the 20-39 group; 7.00 years for the 40 and over group. As is seen these calculated averages are almost precisely the same as the actually observed averages (Table 4). It must be concluded then that the decline of the differences between the age of death of spouses relative to the lengthening of duration-of-marriage is probably spurious. If this con-

clusion is correct then it could be inferred that the immediate environment particular to each couple is not a prime factor in the apparent interdependence of the length of life of husbands and wives.

DISCUSSION

The findings reported establish more firmly the presumption that a real association exists between husbands and wives with respect to length of life. When conditions such as marriage age, age difference at marriage, age of death of the first spouse to die, and age of survivor are rendered constant by the postulates introduced it is found that, according to the mortality characteristics of this sample or of a comparable sample of the general population, the differences between age of death of husbands and wives are always larger than those actually observed. The picture which emerges from the present analysis is that marriage seems to segregate the spouses into pairs of men and women who deviate similarly in their longevity from their respective sex. The clear realization of the modalities by which the association comes about helps us to understand why the coefficient of correlation or any measure of the association may vary from population to population. The manifestations of the association will be affected by the homogeneity or heterogeneity of the population with respect to longevity.

Among the factors that could be considered responsible for the interdependence noted one can only exclude with some assurance the action of the group of elements resulting from the conjugal life common and particular to the two spouses. Such an inference descends from the finding that duration of marriage apparently does not influence the association noted. Pearson and his associates also interpreted their findings to reach a similar conclusion. They assumed that the environmental effect peculiar to each conjugal pair is measured by its action on the correlation between the difference in age of death of spouses and the length of the wife's (or husband's) life. This correlation coefficient was found equal to $r = -.6215 \pm .0139$. Taking random pairs of men and women but with constant age difference at marriage the correlation between difference in age of death of spouses and length of life of one of the spouses became $r = -.6576 \pm .0128$. In view of the insignificant change in the values of r the investigators believed that the factors mentioned had no bearing on the association between husbands and wives relative to length of life. They concluded that "the correlation actually observed between the length of life in two married persons is a measure

of a real tendency towards homogamy, comparable with other cases of assortative mating." Since assortative mating is by the authors defined as the results of the attraction of certain classes of males for certain classes of females, and is distinguished from preferential mating which comes about because males or females of certain classes or having certain characteristics find it less easy to mate than others, it would seem that such a conclusion is too sweeping. Yet, the evidence so far points to the existence of some factor that enters into marital selection and is linked to longevity. Whether this factor is expressed by either the social, the economic, the racial, or the constitutional characteristics that are involved in marital selection remains to be seen.

It is well to recall at this point that although association between husbands and wives relative to certain causes of death has been demonstrated, yet it was also found that the value of the coefficient of correlation between age of death was practically the same for the spouses both of whom died from the same causes and for the couples in whom the two spouses died from different causes. This finding together with those reported here lead to the broad implication that, statistically speaking of course, the elements involved in the conjugal life peculiar to each couple may be important with regard to the break-down of the organism from certain etiological conditions, but does not play a fundamental role in the resistance of the organism to a fatal break-down in general. There are other elements, some of which we know, involved in the determination of longevity and if the results of the present study can be taken at face value it would seem that these elements are reflected in the factors of marital selection and therefore could probably be more precisely identified and their influence measured by extending further the study of the marital group.

SUMMARY

From the death records of 1222 white married couples of whom both spouses died in Washington County, Maryland, between 1898 and 1938, the observed differences between age of death of husband and wife have been compared with differences calculated assuming:

I. Randomly assorted pairs of men and women of given age and age difference at marriage are subject after marriage to the mortality of

(a) the 1222 couples

(b) The U. S. Life Table population as of 1929-1931

(c) The U. S. Life Table population as of 1900-1902.

II. Randomly assorted pairs of men and women of whom one has died at the given age and the widowed who is of given age is subject thereafter to the chances of death for his or her age and sex.

The comparison of the observed with the theoretical differences reveals:

1. The observed differences are significantly lower than the theoretical calculated under any of the hypotheses mentioned.

2. The deviation between theoretical and observed is most marked when the age of death of one spouse and the age of the survivor would lead to the expectation of a large difference between the death of husband and wife.

3. The deviation between theoretical and observed is of the same order for the spouses both of whom died between 1919 and 1938 and for the spouses one or both of whom died between 1898 and 1918.

4. The observed differences decrease with increase in the duration of marriage, but this trend turns out to be spurious and apparently due to the relationship between age of death and duration of marriage.

It is concluded that there exists a real association between the length of life of husband and wife and this association is probably the result of factors that enter into marital selection.

The author wishes to express his gratitude to Dr. A. J. Lotka and Mr. M. Spiegelman whose criticisms were of inestimable help in the preparation of this paper.

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A STUDY OF THE TOTAL VOLUME OF THE HUMAN FINGER TIP AND TOE TIP

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DURING the course of vascular studies on the human finger tip and toe tip certain statistical constants were noticed which were considered worth recording separately. The studies were limited to the right index finger tip and right second toe tip. The finger tip previously defined (Sodeman, '37; Turner, Burch and Sodeman, '37) consists of that portion of the finger distal to a plane passing through the major dorsal and palmar distal creases. The toe tip was arbitrarily defined by comparable skin markings, viz., that portion of the toe distal to a plane passing through the major dorsal and plantar distal creases. In both instances the plane passes proximal to the distal interphalangeal joint.

Since the terminal portion of the toe is larger than the more proximal portion, the method described for determining the volume of the finger tip by measuring the volume of a rigid negative case (Sodeman, '37) could not be employed in these observations. In ascertaining the volume of the finger tip and toe tip negative casts of the parts were first made of a resilient moulage, Negocoll,[1] from which positive casts were made of dental stone. The positives were cut through the creases previously described. The volume of these positive casts was measured by the displacement of mercury which was then weighted. All measurements were made with the subject resting in the supine position and with the part at the level of his heart.

The apparatus employed is shown in Fig. 1. It was constructed of clear Lucite. Part A is essentially a cylinder with a closed broad base. Part B is a bevel-shaped ring made to fit snugly inside of A. It is used to hold the cast in place under the surface of the mercury when

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[1] A preparation of Kern Co., New York.

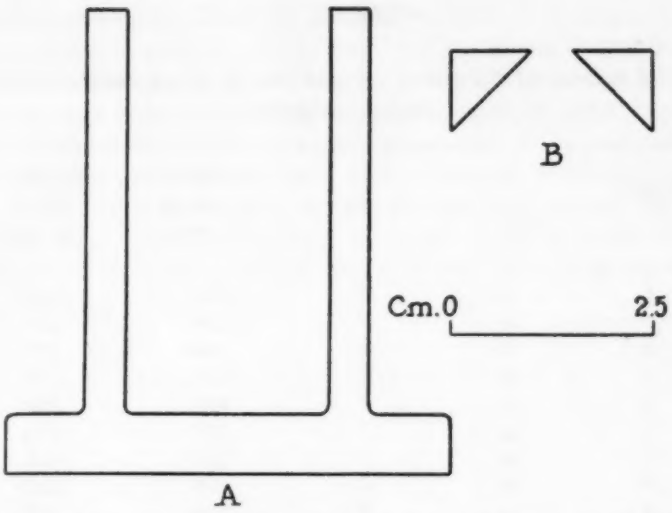

FIG. 1. SCHEMATIC REPRESENTATION OF THE APPARATUS (SEE TEXT)

container A is being filled. Part B is bevelled so as to prevent the formation, and facilitate the removal, of bubbles of air during the filling of A with mercury. In use, ring B is placed inside of container A, and A is filled with mercury. The meniscus of the mercury is levelled to the top of A by pressing a thick, broad, glass slide over the top of the container. The volume of mercury then contained in A is a fixed quantity and is used for the measurements. Some of the mercury contained in A is poured out and saved, ring B is removed, and the positive cast to be measured is placed in A. Ring B is replaced in A, over the cast, and A is refilled with part of the mercury that has been saved. During the refilling of A with mercury, care is taken to keep the cast away from the wall of the container and to remove air bubbles. The mercury meniscus is again levelled off to the top of A with a glass slide. The mercury that is left over represents the volume of the cast. The volume of the mercury is determined from its weight, corrections being made for room temperature. On application of the method to the determinations of the volume of small metal cylinders of known volumes (3 to 7 cc.) the maximum error was less than 3 per cent.

Volume measurements were made of the right index finger tip and second toe tip of 29 normal, white, human subjects ranging in age from 17 to 55 years. The individual variations in sex, age, and volume of

TABLE 1

Total volume of the finger tip and toe tip of 29 normal white human subjects

SUBJECT NO.	AGE (*yrs.*)	SEX	VOLUME OF FINGER TIP (*cu. mm.*)	VOLUME OF TOE TIP (*cu. mm.*)
1	17	F	2821	2952
2	22	F	3108	3611
3	23	F	3222	3162
4	26	F	4174	3027
5	31	F	2922	2948
6	33	F	3789	4364
7	39	F	3530	4182
8	40	F	3080	3938
9	44	F	3222	2988
10	50	F	3981	3160
11	22	M	5364	5312
12	23	M	3781	3595
13	26	M	4846	3694
14	26	M	5516	5538
15	29	M	5242	4788
16	30	M	4163	4104
17	30	M	4600	4220
18	31	M	4640	4338
19	31	M	5090	4132
20	31	M	4895	4426
21	31	M	3624	3950
22	32	M	4503	4528
23	36	M	5034	4256
24	37	M	6022	4842
25	39	M	4113	4497
26	39	M	4020	4051
27	43	M	5034	4664
28	43	M	4412	3454
29	55	M	7088	5224

	Volume of finger tip	*Volume of toe tip*
Mean	4366 ± 113	4059 ± 90 cu. mm.
Range	2821 to 7088	2948 to 5538 cu. mm.
Standard deviation	911 ± 80	720 ± 64 cu. mm.
Coefficient of variation	20.60 ± 1.89 per cent	17.75 ± 1.67 per cent

the parts are recorded in Table 1. The mean volume of the finger tip for the entire group is 4366 ± 113 cu. mm. with a standard deviation of 911 ± 80 cu. mm. and a coefficient of variation of 20.60 ± 1.89 per cent. The mean volume of the toe tip for the group is 4059 ± 90 cu. mm. with a standard deviation of 720 ± 64 cu. mm. and a coefficient of variation of 17.75 ± 1.67 per cent. The statistical constants for the volume of the finger tip and toe tip for the entire group and for each sex group separately, are recorded in Table 2. The coefficient of correlation for the volume of the finger tip and volume of toe tip is +0.760 ± 0.053 (Fig. 2).

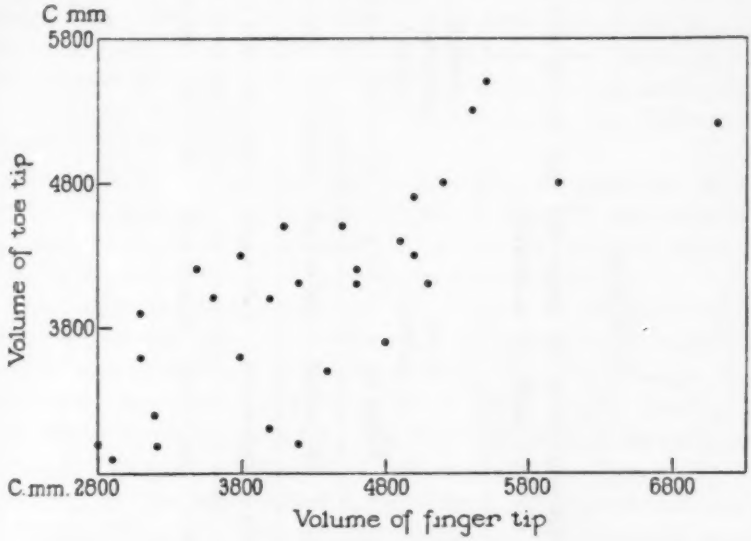

FIG. 2. SPOT GRAPH OF THE RELATIONSHIP OF THE VOLUMES OF THE FINGER TIPS TO THE TOE TIPS

The males and females were considered separately to learn whether there was a difference between the sexes in the volumes of the parts studied. The data for the 9 females (subject number 1 was eliminated because of her youth) were studied statistically by a method for the study of small array of biological data (Mainland, '37). The mean volume of the finger tip is 3448 ± 99 cu. mm. for the females and 4868 ± 126 for the males, a difference of 1420 cu. mm. The probable error of this difference is ±160 cu. mm., indicating a significant dif-

TABLE 2

Statistical constants for the total volume of the finger tip and toe tip for the entire group and each sex separately

	MEAN (*cu. mm.*)		RANGE (*cu. mm.*)		STANDARD DEVIATION (*cu. mm.*)		COEFFICIENT OF VARIATION (*per cent*)	
	Finger tip	Toe tip	Finger tip	Toe tip	Finger tip	Toe tip	Finger tip	Toe tip
Entire group.....	4366 ± 113	4059 ± 90	2821 to 7088	2948 to 5538	911 ± 80	720 ± 64	20.60 ± 1.89	17.75 ± 1.67
Females.....	3488 ± 99	3487 ± 124	2922 to 4174	2948 to 4364	436 ± 69	512 ± 88	12.65 ± 2.04	15.79 ± 2.55
Males.....	4868 ± 126	4405 ± 88	3624 to 7088	3454 to 5538	803 ± 88	566 ± 62	16.49 ± 1.85	12.84 ± 1.45

erence between volumes of the finger tips for the two sex groups. The mean volume of the toe tip is 3487 ± 124 cu. mm. for the females, and 4405 ± 88 for the males, a difference of 918 cu. mm. The probable error of this difference is ±152 cu. mm., indicating a significant difference between the volumes of the toe tips for the two sexes.

COMMENT

The mean volume for the finger tip of this group of 29 normal individuals is 903 cu. mm. less than the mean volume previously reported for a different series of 26 normal, male individuals (Burch and Sodeman). This difference is accounted for in large part by the fact that this group contains 10 female subjects who have been shown to have smaller finger tips than the males. When we consider the mean volume for the finger tip of the males only in our series, this difference is reduced by 56 per cent.

The coefficient of variation for the toe tip is essentially the same as that for the finger tip. This is about equal to those for the weights of the heart, kidneys, liver, and body of normal individuals, which are 17.70, 17.80, 14.80 and 12.78 respectively (cited by Pearl).

The coefficient of correlation for the volumes of the finger tip and toe tip, +0.760 ± 0.053, is greater than the coefficients of correlation for heart weight and body weight, heart weight and kidney weight, heart weight and liver weight, and heart weight and brain weight, which are all essentially expressions of volume. The four latter correlation coefficients are +0.65, +0.56, +0.52, and +0.08 respectively (Greenwood and Brown, '13). One might expect a high correlation between volumes of homologous finger tips and toe tips as they are more closely related anatomically and embryologically than heart and liver, heart and brain, and the like.

In all of these subjects there was some degree of distortion of the shape of the toes due to the wearing of shoes. The extent to which this has influenced the volume of the toe tips and in turn the statistical constants reported above is not known.

SUMMARY

A method is described for the measurement of the volume of the finger tip, toe tip, and other irregular portions of the body. The method consists of first making a negative cast of the part to be measured with

a resilient moulage, then a positive cast of dental stone, and finally measuring the volume of the positive cast by displacing mercury. Volume determinations were made of the right index finger tip and right second toe tip of 29 normal, white subjects and statistical constants were calculated. The male group is found to possess significantly larger finger tips and toe tips than the female group. It is also found that the volumes of the finger tips and toe tips exhibit a high degree of correlation, $+0.760 \pm 0.053$.

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RELATION OF SEASON OF BIRTH TO CERTAIN ATTRIBUTES OF STUDENTS

BY LAURENCE B. CHENOWETH, M.D. AND
RICHARD G. CANNING, A.B.*

THERE is no doubt of the fact that succeeding generations of college students, in late years, have been increasing in average size. Ancient man was relatively small (1), he gained very little in height during the middle ages (2), and the stimulus of a new environment in America added but a small amount to his size in colonial times (3). Statistical studies made in the past two decades have shown a remarkable increase in the height of man. The average height of freshman men in the University of Cincinnati in 1916 was 67.5 inches. By 1936 the average height had increased to 69.9 inches, a gain of almost two and one-half inches in twenty years (4). Since 1936 there has been no increase in average size of freshman students in the University of Cincinnati and the curve of growth seems to have reached a plateau. (Freshmen measured since 1936 show these average heights: 1937, 69.7 ins.; 1938, 69.3 ins.; 1939, 69.6 ins.) Not only has the size of man increased but the rate of growth of children has also been increasing (5).

Why should mankind begin to grow more rapidly after years of relatively slow growth? The answer to this question is, we think, comparatively clear. Casmir Funk, in 1911, first used the term "vitamin" to describe accessory food substances which stimulated growth in laboratory animals. Since then a number of vitamins have been discovered, and their use popularized. Young adults of the present were children after that time and profited by the newer knowledge of nutrition. Cod liver oil, orange juice and other vitamin containing foods became regular articles of diet for infants and children. If vitamins could cause accelerated growth in laboratory animals is it not fair to assume that they could and did cause the same kind of growth in children?

* From the Students' Health Service, University of Cincinnati, L.B.C. Director, R.G.C. Statistician.

All of the studies on prevalence of communicable diseases in the 20th century have indicated a marked decline in the incidence of most of the more serious illnesses of childhood. Such diseases as typhoid fever and dysentery have gradually decreased in amount following attention to purification of water supply. Diptheria and small pox incidence has responded to wholesale immunization of children. Tuberculosis has come under a certain measure of control through early diagnosis and more scientific treatment. Communicable diseases retard growth in children; their partial elimination immediately releases a certain amount of retardation of growth of young people in the aggregate.

The social and economic improvement in the general population may be questioned by some, but mass production of many of the comforts of life has resulted in certain increase in the standard of living. Rapid transportation has resulted, in general, in a fresher, more varied food supply. In spite of the depression those of us who have lived a half-century must recognize that there is a real improvement in living conditions. The general use of refrigeration alone has greatly improved health conditions in the community.

There has also been an improvement in the habits of children. More attention has been paid to the value of physical activity for them, especially play and exercise in the open air. Playgrounds and gymnasia abound everywhere and children may follow a program of healthful activity.

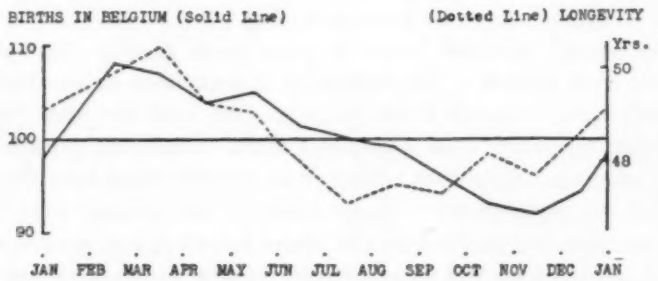

FIG. 1. EXAMPLES OF BASIC ANIMAL RHYTHM

Monthly distribution of births in Belgium (1927-28, 1930-33) is shown by the solid line. Lengths of life in years of 39,004 persons in the eastern United States arranged according to their birth dates are shown by the dotted line. (After Huntington, Season of Birth, published by John Wiley and Sons, Inc. Reprinted by permission.)

We can recognize the probable causes of increase in the size of man, but there are other phenomena in human biology which are not so easily explained. Ellsworth Huntington has made numerous studies on the relation of season of birth to certain human attributes (6). We are permitted to quote certain observations from his recent book. Fig. 1 is derived from his study of the distribution of births in Belgium and longevity in the United States. One notices that more babies are born in that country from February to July than from August to January, and that the curve for length of life follows, in a general way, that for births. These fundamental observations are typical of a certain rhythm which recurs with regularity in the human species. A similar curve was obtained by Huntington for 10,000 prisoners in correctional institutions in New Jersey (see Fig. 8).

It occurred to us to inquire into the relationship between the month of birth and certain attributes which could be easily measured. We had data concerning the size of students, their date of birth and the result of certain psychological examinations. All freshmen are given preliminary physical examinations to determine their physical fitness.

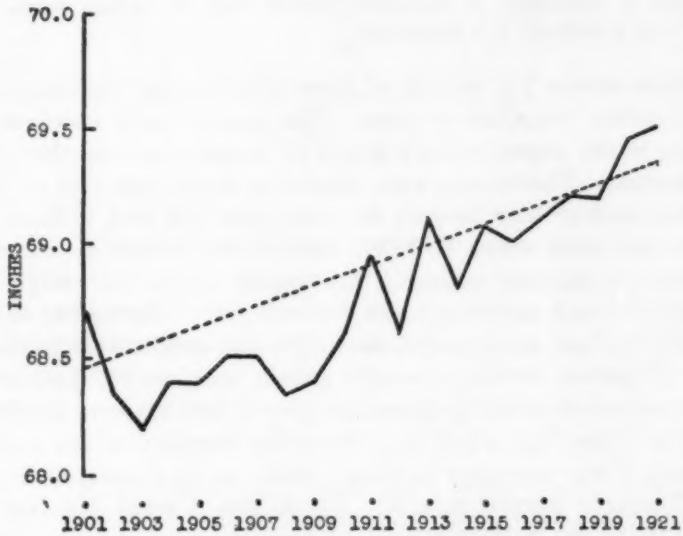

FIG. 2. HEIGHT OF STUDENTS

Height of University of Cincinnati students born in various years. The secular trend is indicated as a dotted line.

FIG. 3. WEIGHT OF STUDENTS

Weight of University of Cincinnati students born in various years. The secular trend is indicated as a dotted line.

The health service has records of these examinations (including personal histories) for about 25 years. The present study, which we are reporting in this paper, covers a period of 18 years and includes 10,005 male students. The records were divided by month and year of birth, and those students born between the years 1904 and 1921 inclusive had enough individuals whose birthdays came in the various months to be considered as adequate samples. The average height and weight was calculated for each month and then for each year. The figures showed two things: First, the averages for height and weight were increasing during the period, showing a secular growth, and, second, the averages did not proceed smoothly up the secular growth line, but were distributed around it. (See Figs. 2 and 3). Before any monthly indices could be calculated, it was necessary to reduce each year to a common level so that all months counted equally. To do this a trend line was put through the yearly averages and was interpolated for the monthly values. Ratios of actual heights and weigths to trend line values were then calculated. This step eliminated secular growth. The second step was to reduce each year to a common level since they had been scattered

around the trend line. This was accomplished by adjusting each year's ratios so that they totaled 1200, and the average for the year would thus be 100 per cent (1200 ÷ 12 months). Now that the years were comparable, typical month indices were calculated simply by finding the averages of the eighteen (yearly) ratios for a month. In some cases great variations in ratios were found and were discarded as random fluctuations so that they did not influence the final result which is shown in Table 1.

TABLE 1

Seasonal indexes of height and weight

MONTH	NUMBER OF MEN	HEIGHT INDEX	WEIGHT INDEX
January	839	100.09	100.02
February	843	99.95	99.62
March	789	100.19	101.04
April	820	99.97	99.35
May	810	100.08	100.33
June	880	100.16	100.58
July	910	100.08	100.04
August	906	99.69	99.86
September	854	99.78	99.87
October	774	100.03	99.45
November	770	99.97	99.46
December	810	100.00	100.26

In making a graph of seasonal indices, a smoothing process was used in order to show only general tendency of the indices rather than the indices themselves. The smoothing formula is one well known in statistical work:

$$B' = \frac{A + 2B + C}{4}$$

Where B' is the "smoothed" value for a given month, B the index for that month, A and C indices for the preceding and following months respectively. The graphs obtained are shown in Figs. 4 and 5.

In comparing our curves with those of Huntington the reader will observe a certain similarity of pattern which recalled the "basic animal rhythm." Huntington suggests that man probably "acquired this funda-

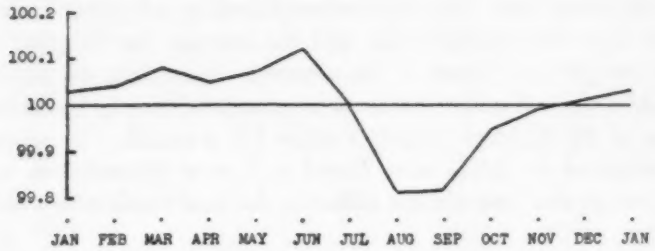

FIG. 4. RELATION OF SEASON OF BIRTH TO HEIGHT

In this chart a similarity may be seen to Fig. 1. Students born in the first half of the year are taller than those born in the remainder of the year.

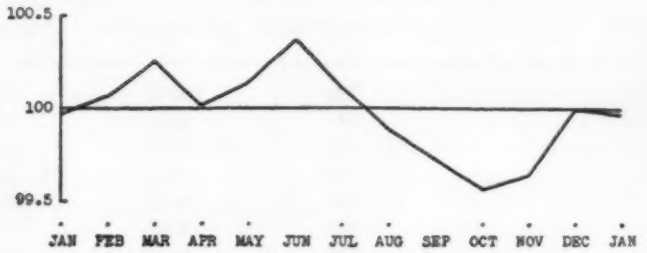

FIG. 5. RELATION OF SEASON OF BIRTH TO WEIGHT

Note the similarity of this curve to Fig. 1 and 4.

mental animal rhythm because it favored the survival of the young." In the spring months temperatures are mild, food is becoming increasingly abundant and diseases are less prevalent. Babies born at this time can be well fed by their mothers and the mothers themselves are getting a more abundant diet. The child's internal organs have had time to be strengthened before the extreme heat of summer sets in. No doubt primative man was influenced by this natural seasonal occurrence and fell into harmony with it. This rhythm has been transmitted down to the present day and there are still traces of it. Size of the individual and even attributes of the mind seem to be affected by the season of birth.

A small sample (489 cases) of the standing of University of Cincinnati students on psychological examination (not I.Q.) was studied, with the results illustrated in Fig. 6. This produced a similar type of curve

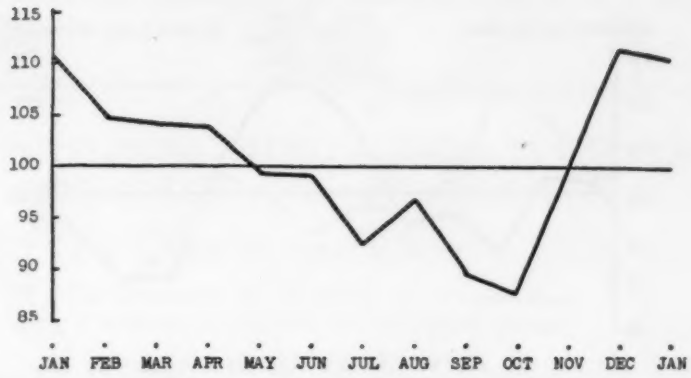

FIG. 6. RELATION OF SEASON OF BIRTH TO RESULTS OF PSYCHOLOGICAL EXAMINATION

In 489 cases studied the best grades were made by students born in December, January, February, March, and April.

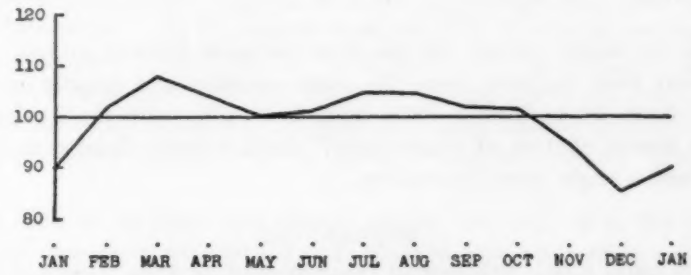

FIG. 7. RELATION OF SEASON OF BIRTH TO COLLEGE GRADES

This is a smoothed curve of the study of college grades of 212 men in relation to their month of birth.

to the others, as did also a smaller group whose college grades were studied (Fig. 7).

A curve diametrically opposed to all the others was obtained when the season of birth was investigated for the 10,005 students mentioned above. This fact is illustrated along with Huntington's study of 10,000 prisoners in New Jersey. The curve for the season of birth of prisoners is just the opposite of that for students, but is similar to other curves in his studies and ours. It is difficult to explain such an apparent contradiction. Can it be that our students, who come almost exclusively

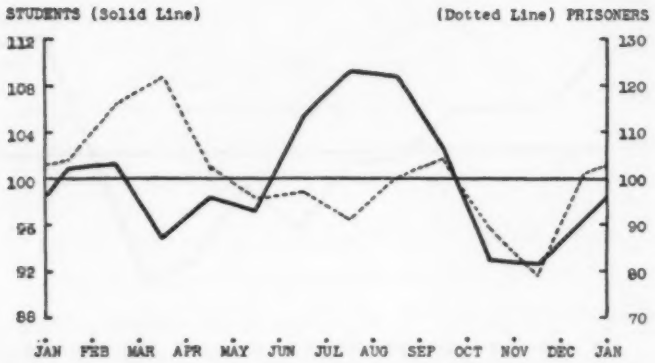

FIG. 8. SEASONAL DISTRIBUTION OF BIRTHS AMONG U.C. STUDENTS AND PRISONERS

It will be noted that these two groups of approximately 10,000 each give very different curves when plotted. The curve for prisoners is after Huntington, Season of Birth, published by John Wiley and Sons, Inc., and reprinted with permission.

from the middle classes, are not from the most favored groups? Is it possible that students from the more wealthy and greatly endowed institutions might show a curve more in keeping with the fundamental basic animal rhythm of Huntington? Such a study from that type of institution might prove interesting.

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A STATISTICAL PHENOMENON INVOLVING HAIR-COLOR AND PHYSICAL TYPES

BY FREDERIC T. JUNG

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ATTEMPTS to classify human beings on the basis of physical characteristics have given rise to an extensive literature with an impressive vocabulary of such adjectives as pyknic, euryosomic, euryoprosopic, macrosplanchnic, and hypersthenic. A variety of such classifications, with particular reference to the ideas of Kretschmer, is given in detail by Weidenreich (1). The possibility that the study of physical types might be fruitful in psychiatry was painstakingly investigated by Schmidt (2), who concluded that knowledge of a patient's habitus was of very little use in the diagnosis of mental disorder. Paterson (3) gave additional reasons for believing that Kretschmer's methodology is unwieldy and scientifically unsatisfactory.

Nevertheless, at times one obtains results that look as if the constitutional propensities correlated with physical type must make a great deal of difference to the individual. A striking illustration is the difference in time of menarche reported by Pryor and Smith (4). They compared the times of beginning menstruation of the nine slenderest and nine broadest of a large series of girls. While the broad-built girls had their menarches on the average at the early age of 11.7 years, no average could be computed for the slender ones because when the study was terminated some had not yet menstruated; it was clear that their average was bound to be something greater than 14.0 years. This would appear to furnish ample justification for the conclusion that the pyknic type of girl menstruates much earlier that the leptosomic. The result, moreover, is of some practical interest because an early menarche in girls, like early puberty in boys, has been shown to be strongly correlated with at least temporary advantages in height, weight, strength, and proficiency in school work.

Another illustration is a fact recorded by Breipohl (5), who classified 284 girls according to the color of their hair. He found that the darkest-haired girls had first menstruated at an average age of 13.02 years, while the lightest-haired had menstruated at 13.31 years.

No comparable data have been found regarding puberty in boys. The popular belief that natives of the torrid zone mature sexually earlier than people of the temperate and frigid zones has been satisfactorily disproved for girls (6), but might still be true for boys; similarly there might exist a difference in puberty-time between light-haired and dark-haired boys. For this reason Jung and Shafton noted the color of hair in 169 boys who were examined in the course of a study on puberty (7). It has been found that a temporary proliferation of breast tissue takes place in the normal boy at puberty, and that the resulting lump under each nipple—the so-called subareolar node—raises the nipple high enough to give statistical significance to measurements of nipple-height. If the nipple-height is graphed as a function of age in boys between the ages of 11 and 17, it is found to reach a maximum within about a year after the fourteenth birthday. Of the 169 boys mentioned, there were 162 between the ages of 12.00 and 16.99, and the measurements obtained from them in October, 1935, gave a maximum nipple-height for the age-group 15.00 to 15.99 years (Table 1).

TABLE 1

Nipple-height and age

AGE	NUMBERS OF BOYS	MEAN NIPPLE-HEIGHTS (in *mm.*) with PE_m
12.0 to 12.9	45	0.56 ± 0.10
13.0 to 13.9	49	1.00 ± 0.10
14.0 to 14.9	38	1.26 ± 0.18
15.0 to 15.9	24	1.64 ± 0.24
16.0 to 16.9	6	0.61 ± 0.11

Now when Jung and Shafton sorted the boys into light, medium, and dark-haired groups and graphed the data separately for these groups, a surprising difference was revealed. It appeared that dark-haired boys had their maximum nipple-height (and so must be supposed to

pass through the changes of puberty) practically two years earlier than light-haired boys (Table 2). Since the swelling under the nipple is often somewhat painful and frequently has caused alarm to the parents of boys whose family histories include cases of cancer of the breast,

TABLE 2

Distribution of hair-color among boys examined for maximum nipple-height

AGE	AVERAGE NIPPLE-HEIGHT (*millimeters*)			DISTRIBUTION OF HAIR-COLOR AMONG BOYS EXAMINED					
				Numbers			*Percentages*		
	Light	Medium	Dark	L	M	D	L	M	D
12.0 to 12.9	0.54	0.45	0.72	33	4	8	73	9	18
13.0 to 13.9	1.07*	0.23	1.05*	26	3	20	53	6	41
14.0 to 14.9	1.56	...	0.93	20	1	17	53	3	45
15.0 to 15.9	2.80*	2.70	—0.04*	11	3	10	46	12	42
16.0 to 16.9	...	...	0.32	1	0	5	17	..	83

* 1.07 ± 0.12; 1.05 ± 0.19; 2.80 ± 0.37; -0.04 ± 0.21

it was of interest to note that apparently the light-haired boys had the swelling in much severer form than the dark-haired ones.

The point of the present paper is that the three observations above involve a curious sort of vicious circle. In the case of hair-color in boys, Jung and Shafton found an increasing percentage of dark-haired boys in the older groups of their particular series (Table 2). Uchida has assembled evidence showing that the darkening of human hair is accelerated during adolescence. Evidently, then, the color of hair is not a satisfactory criterion in sorting out boys during adolescence. The analogy is completed by Pryor and Smith's observation that marked broadening is an essential change of adolescence in girls, so that breadth is not a satisfactory criterion for typing adolescent girls. Obviously the same criticism applies to the results of Briepohl.

The process that is concerned in this statistical illusion can be made clearer by a hypothetical case as follows: Suppose that an investigator is dealing with 160 boys evenly distributed between the ages of 12.00 and 16.99. The youngest group contains only prepubescent boys; intermediate age-groups contain an increasing percentage of postpuberal

boys; and the oldest group contains only boys who have completed the pubertal changes. This gives the following assortment:

Age	*Prepubescent*	*Postpuberal*	*Totals*
12.00 to 12.99	32	0	32
13.00 to 13.99	28	4	32
14.00 to 14.99	16	16	32
15.00 to 15.99	4	28	32
16.00 to 16.99	0	32	32
			160

Consider the boys in groups of four, and suppose that of each group of four, as they complete the changes of puberty, one boy begins and remains light-haired, one boy changes from light-haired to medium, one boy changes from medium to dark, and the fourth boy begins and remains dark. The above table then expands thus:

Age	*Prepubescent*			*Postpuberal*		
	Light	Medium	Dark	Light	Medium	Dark
12.00 to 12.99	16	8	8	0	0	0
13.00 to 13.99	14	7	7	1	1	2
14.00 to 14.99	8	4	4	4	4	8
15.00 to 15.99	2	1	1	7	7	14
16.00 to 16.99	0	0	0	8	8	16

Now one need only rearrange the columns thus:

Age	*Light*		*Medium*		*Dark*	
	Pre	Post	Pre	Post	Pre	Post
12.00 to 12.99	16	0	8	0	8	0
13.00 to 13.99	14	1	7	1	7	2
14.00 to 14.99	8	4	4	4	4	8
15.00 to 15.99	2	7	1	7	1	14
16.00 to 16.99	0	8	0	8	0	16

Examining especially the age-group 14.00 to 14.99 one can see that the dark-haired boys appear to be far ahead of the light-haired ones. But this must be illusory since no distinction as to hair-color was made as the boys were transferred from the prepubescent to the postpuberal classification. The difficulty is the result of sorting by means of an unreliable criterion — a criterion which permits some individuals to

shift from one category to another during the very process one is trying to study.

These results are disquieting because it is possible that a similar fallacy is involved in some generally accepted statistical results. An example is the difference noted between thin and stout people as regards their death rate from tuberculosis (9). If the early stages of tuberculosis frequently include a slow loss of weight, there must be a preceptible tendency for individuals to shift from the stout to the medium and from the medium to the thin categories. In this situation, then, weight is not a satisfactory criterion for sorting the individuals concerned, and the result must be something in the nature of a *petitio principii*. Whatever may be the uses of data of this sort, it is clear that they must not be interpreted as giving some ulterior significance to the ancient classification of people into slim and stout, blond and brunette.

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NOTE

ERRATUM

THROUGH an error, the word "*Nordic*" appeared in place of the word "*Noric*", in the next to the last line, on page 395, of the paper by Griffith Taylor entitled "Blood Groups and Types in Baghdad and Vicinity" (HUMAN BIOLOGY, Vol. 13, No. 3). In the last paragraph on page 397 "Nordic" should read "Noric".

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